My Short Interview with

Richard Dawkins

by Lanny Swerdlow

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Lanny Swerdlow: Hi! With me today is Dr. Richard Dawkins, author of *The Selfish Gene,* the revolutionary book (as far as I'm concerned) *The Blind Watchmaker,* and his newest book, *Climbing* -- er...

Richard Dawkins: *...Mount Improbable.*

Lanny Swerdlow: *Climbing Mount Improbable.* I've got a couple of questions that, ever since I've read the book, I've always wanted to ask you. They're kind of grand in their scope of things, they're not particularly specific. In your book *The Blind Watchmaker,* I believe that you made the argument that the principles of evolution apply everywhere in the universe. In other words, the laws of thermodynamics apply on a planet a hundred-billion light years away from the earth as well as they apply on the earth. So the principles of evolution apply on that planet as much as they would on earth.

Richard Dawkins: It's a less-strong claim than for the laws of thermodynamics. I think for the laws of thermodynamics we more or less *know* that they apply everywhere in the universe. The laws of Darwinian evolution: First off, we don't know if there's life anywhere else in the universe; there may not be. It is actually seriously possible that we may be alone in the universe. Assuming that there is other life in the universe (and I think *most* people think that there is), then my conjecture is that how ever alien and different it may be in detail (the creatures may be so different from us that we may hardly recognize them as living at all), if they have the property of organized complexity and apparent design -- adaptive complexity -- then I believe that something equivalent to Darwinian natural selection -- gradual evolution by Darwinian natural selection; that is, the non-random survival of randomly varying hereditary elements -- will turn out to be applied. All life in the universe, my guess is, will have evolved by some equivalent to Darwinism.

Lanny Swerdlow: Also from reading your book *The Blind Watchmaker,* I kind of pick up the idea that the mechanism of evolution not only apply to origin of species, or DNA survival, but in a way, apply to everything in the universe, from quarks to galaxies.

Richard Dawkins: I would prefer not to say that. I certainly haven't said that in any of my books, and I would be reluctant to say that. I think that something very special happens in the universe, when a self-replicating entity, which DNA is -- DNA is probably not the only one, but

DNA is the self-replicating entity that we know. When that comes into existence, then there is a whole new game that starts. Before that, you had just physics; you have molecules bumping around, forming new molecules according to the ordinary laws of chemistry. Once, by those ordinary laws of chemistry, a molecule springs into existence which is self-replicating, then immediately you have the possibility for Darwinism, for natural selection to occur. Then you have this extraordinary process, which we only know of on this planet, but may exist elsewhere, whereby things start to get more complicated and start to appear as though they've been really designed for a purpose. If you look carefully for what that purpose is, it turns out to be to replicate, to pass on, to propagate that very same DNA, or whatever it might be.

Lanny Swerdlow: People will sometimes look at the physical universe and say it looks like it was designed.... Isn't the fact that a solar system survives based on [the fact that] it has properties which will ensure its survival, versus another solar system that is unstable?

Richard Dawkins: So you're kind of trying to make a Darwinian view of solar systems.... In a way, but let me make a distinction, then, between what we call one-off or single-generation selection, and cumulative, multi-generation selection. A solar system survives because -- let's say, a planet orbiting a star will orbit the star at a particular distance, which is the right distance for that planet and that star. That's the crucial distance. If it was orbiting faster, it would whiz off into deep space; if it were orbiting slower, it would spiral into the star. So, there is a kind of selection of planets to be orbiting at the right speed and at the right distance from their stars.

But that's not cumulative selection, that's one-off, single-generation selection. It's like one generation of biological selection. It's like finches who have the wrong size of beak for a hard winter. The ones with the wrong size of beak die, so in the next winter, the next generation have all got the right size of beak. That's one generation.

What's really crucial about biological evolution is that that doesn't stop at one generation, it goes on to the next and the next and the next, and it takes hundreds, it takes *thousands* of generations to build up, cumulatively, the really impressive adaptive complexity that we get in living things, like eyes and elbow joints. So, that's the reason why solar systems don't look very *impressively* designed, whereas living bodies look very, *very* impressively designed indeed. They've been through many generations of cumulative selection.

Lanny Swerdlow: I was listening to your previous interview and a question popped into my mind that I wanted to ask; it's kind of a hot-button question. They asked you a question about children being gullible and you explained that this is an adaptive mechanism, that they have a lot to learn when they're young, so they'll take in a lot of information. Some of the information is good, some of the information is bad, and the problem is that once they've taken in this information they're pretty well set for the rest of their lives. Is this one of the reasons explaining why religion and belief in supernatural forces is so ingrained in people because it's indoctrinated into them when they're very young and very gullible? and even when they get older and can start reasoning better, it's been so ingrained into them that they can't get out of it?

Richard Dawkins: Yes, I do think that. What would be consistent with that view is the fact that (really, rather remarkably) of the people who are religious, the religion that they have is almost always the same as that of their parents. Very occasionally, it isn't. This is an almost unique feature about people's beliefs. We talk about a child as being a 4-year-old Muslim or a 4-year-old Catholic. You would never dream about talking about a 4-year-old economic monitorist or a 4-year-old neo-isolationist, and yet, you can see the parallel.

Lanny Swerdlow: Yes!

Richard Dawkins: Children really ought not be spoken of as a Catholic child or a Muslim child. They ought to be allowed to grow until they're old enough to decide for themselves what their beliefs about the cosmos are. But ... the fact [is] that we *do* treat [children] that way, and ... parents seem to be regarded as having a unique right to impose their *religious* beliefs on their child; whereas, nobody thinks they're going to impose their beliefs about -- I don't know -- why the dinosaurs went extinct, or something of that sort. But religion is different. And I do think that you can explain an awful lot about religion if you assume that children start out gullible. Anything that is told to them with sufficient force -- particularly if it's reinforced by some kind of threat, like, "If you don't believe this, you'll go to hell when you die" -- then it is going to get passed on to the next generation. Above all, "You must believe this, and when you grow up, you must teach your children the same thing." That, of course, is precisely how religions get promoted, how they do get passed on from generation to generation.

Lanny Swerdlow: Almost sounds Darwinian! Last question, last night ... I saw ... the program, and I read about you, and then they had a little squib, in the program, of somebody opposing you. I was kind of taken aback by that.... Obviously, what you're talking about is very controversial, because some people who are religious feel it's attacking their very basic religious beliefs. I wonder if you might have a comment on -- here's a *science* group that, for some reason, feels *so* pressured by religions (or something), that they'll do an extraordinary thing by putting a religious argument in a Program; something they've never done before. How do you react to that?

Richard Dawkins: I think that you're overreacting to this particular thing. I think that when somebody's trying to sell tickets, it's quite good to put in a -- er, some negative, um -- I don't blame them for that at all. The particular extract that was put in was not by any known person. It was just a letter to the editor of a journal in which I'd had an article published. The person who wrote it is not somebody I've ever heard of; it was not a refereed article. It was just that if you say anything in the press that *remotely* treads on people's religious toes, all hell breaks loose. You always get a great mailbag full of stuff. Now, I just throw it straight in the bin! Newspapers, obviously, have a duty to publish some random selection of the papers that they get in, and I think that's what happened in this case.

Lanny Swerdlow: Finally, ... do you see the concepts of evolution as sort of an atheistic explanation of the origins of life? And, is that why the religions have so much problem with it, because it undermines their basic foundations?

Richard Dawkins: Well, evolution is different about this, because there are a large number of evolutionists who are also religious. You cannot be both *sane* and *well educated* and disbelieve in evolution. The evidence is so strong that any sane, educated person has *got* to believe in evolution. Now there are plenty of sane, educated, religious people: there are professors of theology, and there are bishops ... and so obviously they all believe in evolution or they wouldn't have gotten where they have because they would be too stupid or too ignorant. So, it is a fact that there are evolutionists who are religious and there are religious people who are evolutionists.

My own personal feeling is that it is rather difficult. I find that the reason that I am no longer religious is that the argument from design has been undermined by evolution. So if the basis for your religion is the argument from design, if the reason why you are religious is that you look at the world and you say, "Isn't it beautifully designed! Isn't it elegant! Isn't it complicated!" then Darwinism really does pull the rug out from under that argument. If your reason for being religious has nothing to do with that, if your reason for being religious is some still, small voice inside you which utterly convinces you, then the argument from design, I suppose, has no bearing on that. But what, I think, Darwinism has done is utterly to destroy the argument from design which, I believe, is probably, historically, the dominant reason for believing in a supernatural being.

Lanny Swerdlow: Thank you very much! I sure appreciate your time.

Richard Dawkins: Thank you.

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The Likelihood of God

-- by Richard Dawkins

(source of excerpt unknown)

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I suspect that most people have a residue of feeling that Darwinian evolution isn't quite big enough to explain everything about life. All I can say as a biologist is that the feeling disappears progressively the more you read about and study what is known about life and evolution.

I want to add one thing more. The more you understand the significance of evolution, the more you are pushed away from the agnostic position and towards atheism. Complex, statistically improbable things are by their nature more difficult to explain than simple, statistically probable things.

The great beauty of Darwin's theory of evolution is that it explains how complex, difficult to understand things could have arisen step by plausible step, from simple, easy to understand beginnings. We start our explanation from almost infinitely simple beginnings: pure hydrogen and a huge amount of energy. Our scientific, Darwinian explanations carry us through a series of well-understood gradual steps to all the spectacular beauty and complexity of life.

The alternative hypothesis, that it was all started by a supernatural creator, is not only superfluous, it is also highly improbable. It falls foul of the very argument that was originally put forward in its favour. This is because any God worthy of the name must have been a being of colossal intelligence, a supermind, an entity of extremely low probability -- a very improbable being indeed.

Even if the postulation of such an entity explained anything (and we don't need it to), it still wouldn't help because it raises a bigger mystery than it solves.

Science offers us an explanation of how complexity (the difficult) arose out of simplicity (the easy). The hypothesis of God offers no worthwhile explanation for anything, for it simply postulates what we are trying to explain. It postulates the difficult to explain, and leaves it at that. We cannot prove that there is no God, but we can safely conclude the He is very, very improbable indeed.

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Richard Dawkins' Evolution

by Ian Parker

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Richard Dawkins, arch-Darwinist, author of "The Selfish Gene", and Britain's village atheist, has a reputation for intellectual austerity and single-mindedness: he is a professor who will not stop professing. Because he knows the meaning of life (which is evolution by natural selection), and because others do not know it, or only half know it, or try willfully to mess with its simple, delicious truth, he promotes his subject in a way that -- if you wanted to drive him crazy -- you could call evangelical. Besides writing his beautifully pellucid and best-selling books on Darwinian themes, Dawkins, who is a zoologist by training, is forever finding other opportunities to speak on behalf of evolution and on behalf of science. Now in his mid-fifties, he has become a familiar floppy-haired figure on television and in the newspapers, where he energetically scraps with bishops and charlatans. He recently argued, for example, that astrologers should be jailed, and he has complained warmly about what he alleges are one novelist's slurs on his profession. ("Sir," he wrote to the Daily Telegraph, "Fay Weldon's incoherent, petulant and nihilistic rant is the sort of thing I remember scribbling as a disgruntled teenager.") Dawkins regards it as his duty not to let things pass, or rest, and as he makes his slightly awkward -- but still dashing -- progress through the British media he occasionally encounters charges of arrogance and aggressiveness. It is not universally agreed that he is science's ideal public-relations director.

This, though, is now his job. Dawkins has been appointed the first Charles Simonyi Professor of Public Understanding of Science at Oxford University -- Simonyi, the sponsor, being a soft-spoken Hungarian-born American made rich by long employment at Microsoft. Dawkins will now be expected to do more of what he has been doing: to write books, appear on television, and help counter what he calls "the stereo- type of scientists' being scruffy nerds with rows of pens in their top pocket" -- an image that he regards, with a typical level of moderation, as "just about as wicked as racist stereotypes." Richard Dawkins has been made the new Oxford Professor of Being Richard Dawkins.

Because of all his media activity -- those bright, staring eyes on television -- it has sometimes been possible to forget that Dawkins's reputation is founded on a remarkable writing achievement. Twenty years ago, with "The Selfish Gene" (1976), Dawkins managed to secure a wildly enthusiastic general readership for writing that was also of interest to his professional colleagues: he seduced two audiences at once. Biologists found themselves learning about their subject not from a paper in a learned journal but -- as in an earlier tradition of scientific disclosure, one that includes Darvin's own work -- from a book reviewed in the Sunday press. His later books, "The Blind Watchmaker" (1986) and "River Out of Eden" (1995), had a similar effect.

Like so much of Dawkins's enterprise, the inspiration for "The Selfish Gene" was rebuttal: the book was designed to banish an infuriatingly widespread popular misconception about evolution. The misconception was that Darwinian selection worked at the level of the group or the species, that it had something to do with the balance of nature. How else could one understand, for example, the evolution of apparent "altruism" in animal behavior? How could self-sacrifice, or niceness, ever have been favored by natural selection? There were answers to these questions, and they had been recently developed, in particular, by the evolutionary biologists W. D. Hamilton, now at Oxford, and George Williams, of the State University of New York at Stony Brook. But their answers were muted. Dawkins has written, "For me, their insight had a visionary quality. But I found their expressions of it too laconic, not full-throated enough. I was convinced that an amplified and developed version could make everything about life fall into place, in the heart as well as in the brain."

Essentially, their insight was that altruism in nature was a trick of the light. Once one understands that evolution works at the level of the gene -- a process of gene survival, taking place (as Dawkins developed it) in bodies that the gene occupies and then discards -- the problem of altruism begins to disappear. Evolution favors strategies that cause as many of an animal's genes as possible to survive -- strategies that may not immediately appear to be evolutionarily sound. In the idea's simplest form, if an animal puts its life at risk for its offspring, it is preserving a creature -- gene "vehicle," in Dawkins's language -- half of whose genes are its own. This is a sensible, selfish strategy, despite the possible inconvenience of death. No one is being nice.

Starting from this point, "The Selfish Gene" took its reader into more complex areas of animal behavior, where more persuasion was needed -- more mathematics, sometimes, and more daring logical journeys. Dawkins assumed no prior knowledge of the subject in his reader, yet was true to his science. He made occasional ventures into ambitious prose (genes "swarm in huge colonies, safe inside gigantic lumbering robots"), but mostly relied on sustained clarity, the taming of large numbers, and the judicious use of metaphor. The result was exhilarating. Upon the book's publication, the Times called it "the sort of popular science writing that makes the reader feel like a genius." Douglas Adams, a friend of Dawkins's and the author of "The Hitchhiker's Guide to the Galaxy," found the experience of reading it "one of those absolutely shocking moments of revelation when you understand that the world is fundamentally different from what you thought it was." He adds, "I'm hesitating to use the word, but it's almost like a religious experience."

Twenty Years later, Richard Dawkins finds himself something of a curiosity -- a scientist with an honorary doctorate of letters, a philosopher with a CD-ROM deal, an ambassador who acknowledges that he is "not a diplomat," and a rather reticent man who in print is by turns flamboyantly scornful and boundlessly enthusiastic. I had been told that he "thinks scientifically and only scientifically"so when I recently visited him at his apartment in central Oxford -- he has since moved house -- I was surprised to find a great many wooden carrousel animals there, and a lot of cushions, which made a kind of sitcom chute from chair to floor. It was interesting, too, to note the cupboard by the living-room door, which had been lovingly hand-painted to represent the details of the life of Richard Dawkins: a childhood in Africa, a college room, a computer, a head of Charles Darwin, a young daughter "building castles in the air," and a panel suggesting an international reputation. The cupboard, I learned, was painted by Dawkins's mother, and was a gift to her son on his fiftieth birthday. (He is now fifty-five.) The horses and other large wooden animals were brought into the apartment by Lalla Ward, Dawkins's wife (his third), who inherited the collection. She used to be an actress, and it has caused some joy in the British press that Professor Dawkins is now married to a woman who played the part of an assistant to the television science-fiction character Doctor Who. (It's as if Stephen Jay Gould had married Lieutenant Uhura.)

Having finished with some students, Dawkins now appeared in the living room. A handsome matinee version of an Oxford don, he was wearing leather slippers and blue corduroy trousers. His manner managed to suggest both caution and assurance -- he has something of the air of a bullied schoolboy suddenly made prefect.

We talked about God, and other obstructions to an understanding of science. Dawkins complained of a "fairly common pattern in television news: right at the end a smile comes onto the face of the newsreader and this is the scientific joke -- some scientist has proved that such and such is the case." He went on, "And it's clearly the bit of fun at the end, it's not serious at all. I want science to be taken seriously, because, after all, it's less ephemeral -- it has a more eternal aspect than whatever the politics of the day might be, which, of course, gets the lead in the news."

Much of what is important to others is ephemeral to Dawkins. He shares his life with Darwin's idea -- one that the philosopher Daniel Dennett, of Tufts, has called "the single best idea anyone has ever had." Dawkins does have tastes in art and in politics. He does have friends, and he has become more sociable in recent years. But his non-scientific tastes seem to shrink at the touch of science. He admires Bach's "St. Matthew Passion," but told me, "I really do feel what Bach might have done with some really decent inspiration, considering what he achieved with what he had." He was imagining "Evolution," the oratorio.

While we were talking at his apartment, the telephone rang often. Inevitably, Dawkins was one of the first to be featured in a jokey column in the Guardian called "Celebrity Scholars: A Cut-Out-and-Keep Guide to the Academics Whose Phones Are Always Ringing." He is not a geneticist, but because he once wrote a book that had the word "gene" in the title he is frequently asked to comment on contemporary genetic issues -- the discovery of genes "for" this or that, say, or the ethics of genetic engineering -- and he ordinarily refers journalists to colleagues with the relevant expertise.

Dawkins is still most comfortable dealing with the pure, incontestable logic of Darwinian evolution. His fifth book, "Climbing Mount Improbable," will be published this month in the United States. With a fresh, unifying metaphor, Dawkins here continues his long-term project to make natural selection as Persuasive and comprehensible to others as it is to him. On the peaks of Mount Improbable, he explains, are to be found, say, a spiderweb and the camouflage of a stick insect. It would seem that one has to scale sheer cliffs of improbability to reach such complexity by natural selection. For one thing, natural selection does not Provide for developments that will turn out to be advantageous only after a million years of evolution. What use is a wing stub? What good is a half-evolved eye? But Dawkins points out the long, winding paths that lead to the summit of Mount Improbable -- paths that have the gentlest of slopes and require no freakish upward leaps. He takes his reader up the slope from no eye to eye: a single (not entirely useless) photosensitive cell caused by genetic mutation, a group of such cells, a group arranged on a curve, and so forth. Dawkins knows that the length of this path will always daunt some readers. "Human brains," he writes, "though they sit atop one of its grandest peaks, were never designed to imagine anything as slow as the long march up Mount Improbable."

Dawkins took me to lunch in New College, where he has been a fellow for twenty-six years -- "a bread-and-butter worker," he says. He and Lalla Ward and I sat at a long wooden table in a high-ceilinged room and ate soup with huge silver spoons, and between courses Lalla Ward set herself the task of making a rather introspective-looking college employee return her smile.

As a writer and broadcaster and propagandist, Dawkins has now left the laboratory far behind him. Wondering if this was a source of regret, I asked him if he would exchange what he had achieved for a more traditional scientific discovery. "I'd rather go to my grave having been Watson or Crick than having discovered a wonderful way of explaining things to people," he says. "But if the discovery you're talking about is an ordinary, run-of-the-mill discovery of the sort being made in laboratories around the world every day, you feel: Well, if I hadn't done this, somebody else would have, pretty soon. So if you have a gift for reaching hundreds of thousands -- millions -- of people and enlightening them, I think doing that runs a close second to making a really great discovery like Watson and Crick."

After lunch, we walked back to the apartment, a hundred yards away, passing through a Chinese-style flock of student cyclists. In his cluttered living roorn, Dawkins talked about his past. His father, he said, worked in the British colonial service in Nyasaland, now Malawi, but with the outbreak of the Second World War he moved to Kenya to join the Allied forces. Richard was born in Nairobi, in 1941. In 1946, his father unexpectedly inherited a cousin's farm near Chipping Norton in Oxfordshire, and in 1949 the family returned to England. Dawkins drifted into zoology at Oxford, but he became fully engaged in it only when, some time after his arrival, the speculative nature of the subject revealed itself to him. "I think students of biochemistry, for example, before they can even start, probably have to get a lot of textbook knowledge under their belt," he says. "In animal behavior, you can jump straight into controversy and argument."

While still an undergraduate, Dawkins was taught by Niko Tinbergen, the Dutch-born animal behaviorist (and, later, Nobel Prize winner), who had him read doctoral theses in place of the standard texts. Dawkins remembers reading one thesis about two species of grasshopper, *Chorthippus brunneus* and *Chorthippus biguttulus*, that coexist on the European continent and look the same. "The only known difference between them is that they sing differently," he says. "They don't reproduce with each other, bemuse they sing differently. As a consequence of their not reproducing together, they're called two separate species -- and they are. It' s not that they cannot breed but that they do not. Dawkins continues, "In the thesis that I read, the author found it was easy enough to fool them to mate with each other by playing them the song of their own species. And I got a feeling for how you design experiments when you're faced with a problem like this -- and the intellectual importance of this first process in evolution. It happened to be grasshoppers, but it's the same process for all species on earth. They've all diverged from an ancestral species, and that process of divergence is the origin of species -- it's the fundamental process that has given rise to all diversity on earth."

Dawkins graduated in 1962, and started immediately on his doctorate, for which he developed a mathematical model of decision-making in animals. In 1967, he married for the first time, and took up a post as an assistant professor of zoology at Berkeley. He became "a bit involved" in the dramas of the period, he told me. He and his wife marched a little, and worked on Eugene McCarthy's Presidential campaign. (Although colleagues today see Dawkins as apolitical, and enemies have sought to project a right-wing agenda onto his science, he has always voted on the left.) He returned to Oxford after two years and continued research into the mathematics of animal behavior, making much use of computers. In the winter of 1973-74, a coal miners' strike caused power cuts in Britain, preventing Dawkins from properly continuing his computer-driven research. He decided to write a book, which he finished a year later with "a tremendous momentum." The book was "The Selfish Gene," and its Preface starts, "This book should be read almost as though it were science fiction. It is designed to appeal to the imagination. But it is not science fiction: it is science."

When "The Selfish Gene" was published, in 1976, readers began writing to Dawkins that their lives had been changed; and most were pleased with the change. (Dawkins's peripheral theory of the self-replicating "meme," as a way of understanding the transmission of human culture and ideas -- a meme for religion, or for baseball hats worn backward -- began its impressive self-replicating career.) But Dawkins also caught the attention of his peers. Helena Crooning, a British philosopher of science, explains the response this way: "Very often in science one finds that there are ideas in the air, and lots of people hold them, but they don't even realize they hold them. The person who can crystallize them, and lay out not only the central idea but its implications for future scientific research can often make a tremendous contribution. And I think that's what 'The Selfish Gene' did. Lots of scientists, they'd been Darwinians all their lives, but they'd been inarticulate Darwinians. And now they really understood what was foundational to Darwinism and what was peripheral. And once you understand what is foundational, then you begin to deduce conclusions." In a variety of fields, Dawkins proved to be a catalyst.

In the twenty years following the publication of "The Selfish Gene" -- years of teaching, fatherhood, wealth, and encroaching responsibilities as the British media's favorite scientist -- Dawkins has published any number of papers and articles, and four more books, including "The Blind Watchmaker," a best-selling study of Darwinian design, written with the reach and elegance of "The Selfish Gene." On a rolling mass of ants in Panama, for instance:

> I never did see the queen, but somewhere inside that boiling ball she was the central data bank, the repository of the master DNA of the whole colony. Those gasping soldiers were prepared to die for the queen, not because they loved their mother, not because they had been drilled in the ideals of patriotism, but simply because their brains and their jaws were built by genes stamped from the master die carried in the queen herself. They behaved like brave soldiers because they had inherited the genes of a long line of ancestral queens whose lives, and whose genes, had been saved by soldiers as brave as themselves. My soldiers had inherited the same genes from the present queen as those old soldiers had inherited from the ancestral queens. My soldiers were guarding the master copies of the very instructions that made them do the guarding. They were guarding the wisdom of their ancestors.

These have been twenty Years of rising confidence and influence. "The world must be full of people who are biologists today rather than physicists because of Dawkins," John Maynard Smith, the senior British biologist, says. Outside the universities, in a climate newly friendly to accessible science books, Dawkins has become a literary fixture. Ravi Mirchandani, who published Dawkins at Viking, says, "If you're an intelligent reader, and you read certain literary novels that everybody has to read, along with seeing Tarantino movies, then reading Richard Dawkins has become part of your cultural baggage."

Dawkins's version of evolution also attracts critics, for it is dazzlingly digital. It features "robots" and "vehicles" and DNA, not flesh and fur; some evolutionary biologists regard him as a kind of reductionist fanatic -- an "ultra-Darwinist" who overplays the smooth mathematical progress of natural selection and its relevance to an animal's every characteristic, every nook and cranny. A biting review of "The Selfish Gene" by Richard Lewontin, of Harvard, published in Nature, talked of "Dawkins's discovery of vulgar Darwinism." It was an error of "new Panglossians," Lewontin wrote, to think that "all describable behavior must be the direct product of natural selection." (This is the sin of excessive "adaptationism.") In the continuing debate, Maynard Smith, George Williams, and W. D. Hamilton are in one camp; in the other are Steven Rose, Lewontin, Leon Kamin (these three collaborated on a book called "Not in Our Genes"), and Stephen Jay Gould, the man who is in many ways Dawkins's American counterpart. Dawkins and Gould have undertaken the same project -- eliminating the barrier between the practice of science and its communication to a wider audience. And they stand shoulder to shoulder against the creationists. But they would not want to be stuck in the same elevator.

In 1979, Gould and Lewontin wrote a famous paper called "The Spandrels of San Marco and the Panglossian Paradigm: A Critique of the Adaptationist Programme," which argued that natural selection can be limited by or can be a by-product of an animal's architecture in the way that the spandrels of St. Mark's in Venice (described by the authors as "the tapering triangular spaces formed by the intersection of two rounded arches at right angles") are "necessary architectural by-products of mounting a dome on rounded arches," and were not designed to be painted upon, although that might be how it looks. Gould also contests the evolutionary "gradualism" of the Dawkins camp, and promotes "punctuated equilibrium" -- the theory that evolution goes by fits and starts. Gould's opponents suspect him of exaggerating his differences with contemporary Darwinism: they want him to know that one can make a stir in science without making a revolution. Dawkins said, "I really want to say that there are no major disagreements." But he added, "I think the tendency of American intellectuals to learn their evolution from him is unfortunate, and that's putting it mildly."

Earlier this year, Richard Dawkins took part in a public debate in a hall on the edge of Regent's Park, in central London. The debate, which was organized by the Oxford-based Jewish society L'Chaim, set Dawkins against the very distinguished Jewish scholar Rabbi Adin Steinsaltz. The question to be debated was "Does God exist?" In the lobby, tempers were fraying as it became clear that the event had been greatly oversubscribed. Three hundred people were sent away, and one could hear cries of "I've got a ticket! I'm not moving!" and so on

The two speakers took their places on the wooden stage of the main hall, and were introduced with some old Woody Allen jokes. Dawkins then spoke of design, and of the miserable logic of trying to use a God -- who must be complex -- as an explanation of the existence of complex things. By contrast, he said, "Darwinian evolution explains complicated things in terms of simple things." In reply, Rabbi Steinsaltz made an occasionally witty but rather digressive speech, in which he always seemed to lose interest in a point just before he made it. He talked of giraffs, though it was not entirely clear what we were to think of them. ("'You know these animals. Beautiful eyes.") Dawkins found himself arguing with a theist of his imagination rather than with the man to his right, who was frustratingly unresponsive to his favorite evolutionary sound bites. ("Not a single one of your ancestors died young. They all copulated at least once.") One member of the society told me that Dawkins was significantly gentler than he used to be at these meetings: he used to go into "a frenzy of savage attack, saying all religious people are delusional, weak-minded." That night, he seemed to win the debate, speaking in his curious shy, confident way.

This is the kind of event that presents the new Professor of Public Understanding with a problem: he has become wary of the atheist's reputation suffocating the evolutionist's. And yet he cares deeply about religion; he is sure that it matters. "It's important to recognize that religion isn't something sealed off in a watertight compartment," he says. "Religions do make claims about the universe -- the same kinds of claims that scientists make, except they're usually false." Richard Dawkins is not a great one for cultural relativism. He says, "The proof of the pudding is: When you actually fly to Your international conference of cultural anthropologists, do you go on a magic carpet or do you go on a Boeing 747?"

In Dawkins's kitchen in Oxford, a headline had been torn out of a newspaper and stuck on the wall, in an office-humor sort of way It read "THE PROBLEMS OF DAWKINISM." The main problem, which is experienced particularly by those who have not read his books, remains one of tone. Douglas Adams says, laughing, "Richard once made a rather wonderful remark to me. He said something like 'I really don't think I'm arrogant, but I do get impatient with people who don't share with me the same humility in front of the facts.'" The glory of Darwinism fills Dawkins's brain, but it drops out of the brains of others, or is nudged out by God or Freud or football or Uranus moving into Aquarius, and Dawkins finds this maddening. "It is almost as if the human brain were specifically designed to misunderstand Darwinism, and to find it hard to believe," he has written. Dawkins does not seem to have developed this point, and he sometimes allows disdain or mockery to take the place of a clearer understanding of it -- the evolution of resistance to evolution. Even the admiring Charles Simonyi, who funds the job for which Richard Dawkins is so precisely suited, and so precisely unsuited, says he has urged Dawkins to "tame his militancy."

"I'm a friendly enough sort of chap," Dawkins told me. "I'm not a hostile person to meet. But I think it's important to realize that when two opposite points of view are expressed with equal intensity, the truth does not necessarily lie exactly halfway between them. It is possible for one side to be simply wrong."

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The Improbability of God

by Richard Dawkins

The following article is from Free Inquiry MagazineVolume 18, Number 3.

Much of what people do is done in the name of God. Irishmen blow each other up in his name. Arabs blow themselves up in his name. Imams and ayatollahs oppress women in his name. Celibate popes and priests mess up people's sex lives in his name. Jewish *shohets* cut live animals' throats in his name. The achievements of religion in past history - bloody crusades, torturing inquisitions, mass-murdering conquistadors, culture-destroying missionaries, legally enforced resistance to each new piece of scientific truth until the last possible moment - are even more impressive. And what has it all been in aid of? I believe it is becoming increasingly clear that the answer is absolutely nothing at all. There is no reason for believing that any sort of gods exist and quite good reason for believing that they do not exist and never have. It has all been a gigantic waste of time and a waste of life. It would be a joke of cosmic proportions if it weren't so tragic.

Why do people believe in God? For most people the answer is still some version of the ancient Argument from Design. We look about us at the beauty and intricacy of the world - at the aerodynamic sweep of a swallow's wing, at the delicacy of flowers and of the butterflies that fertilize them, through a microscope at the teeming life in every drop of pond water, through a telescope at the crown of a giant redwood tree. We reflect on the electronic complexity and optical perfection of our own eyes that do the looking. If we have any imagination, these things drive us to a sense of awe and reverence. Moreover, we cannot fail to be struck by the obvious resemblance of living organs to the carefully planned designs of human engineers. The argument was most famously expressed in the watchmaker analogy of the eighteenth-century priest William Paley. Even if you didn't know what a watch was, the obviously designed character of its cogs and springs and of how they mesh together for a purpose would force you to conclude "that the watch must have had a maker: that there must have existed, at some time, and at some place or other, an artificer or artificers, who formed it for the purpose which we find it actually to answer; who comprehended its construction, and designed its use." If this is true of a comparatively simple watch, how much the more so is it true of the eye, ear, kidney, elbow joint, brain? These beautiful, complex, intricate, and obviously purpose-built structures must have had their own designer, their own watchmaker - God.

So ran Paley's argument, and it is an argument that nearly all thoughtful and sensitive people discover for themselves at some stage in their childhood. Throughout most of history it must have seemed utterly convincing, self-evidently true. And yet, as the result of one of the most astonishing intellectual revolutions in history, we now know that it is wrong, or at least superfluous. We now know that the order and apparent purposefulness of the living world has come about through an entirely different process, a process that works without the need for any designer and one that is a consequence of basically very simple laws of physics. This is the process of evolution by natural selection, discovered by Charles Darwin and, independently, by Alfred Russel Wallace.

What do all objects that look as if they must have had a designer have in common? The answer is statistical improbability. If we find a transparent pebble washed into the shape of a crude lens by the sea, we do not conclude that it must have been designed by an

optician: the unaided laws of physics are capable of achieving this result; it is not too improbable to have just "happened." But if we find an elaborate compound lens, carefully corrected against spherical and chromatic aberration, coated against glare, and with "Carl Zeiss" engraved on the rim, we know that it could not have just happened by chance. If you take all the atoms of such a compound lens and throw them together at random under the jostling influence of the ordinary laws of physics in nature, it is *theoretically* possible that, by sheer luck, the atoms would just happen to fall into the pattern of a Zeiss compound lens, and even that the atoms round the rim should happen to fall in such a way that the name Carl Zeiss is etched out. But the number of other ways in which the atoms could, with equal likelihood, have fallen, is so hugely, vastly, immeasurably greater that we can completely discount the chance hypothesis. Chance is out of the question as an explanation.

This is not a circular argument, by the way. It might seem to be circular because, it could be said, *any* particular arrangement of atoms is, with hindsight, very improbable. As has been said before, when a ball lands on a particular blade of grass on the golf course, it would be foolish to exclaim: "Out of all the billions of blades of grass that it *could* have fallen on, the ball actually fell on this one. How amazingly, miraculously improbable!" The fallacy here, of course, is that the ball had to land somewhere. We can only stand amazed at the improbability of the actual event if we specify it *a priori*: for example, if a blindfolded man spins himself round on the tee, hits the ball at random, and achieves a hole in one. That would be truly amazing, because the target destination of the ball is specified in advance.

Of all the trillions of different ways of putting together the atoms of a telescope, only a minority would actually work in some useful way. Only a tiny minority would have Carl Zeiss engraved on them, or, indeed, *any* recognizable words of any human language. The same goes for the parts of a watch: of all the billions of possible ways of putting them together, only a tiny minority will tell the time or do anything useful. And of course the same goes, *a fortiori*, for the parts of a living body. Of all the trillions of trillions of ways of putting together the parts of a body, only an infinitesimal minority would live, seek food, eat, and reproduce. True, there are many different ways of being alive - at least ten million different ways if we count the number of distinct species alive today - but, however many ways there may be of being alive, it is certain that there are vastly more ways of being dead!

We can safely conclude that living bodies are billions of times too complicated - too statistically improbable - to have come into being by sheer chance. How, then, did they come into being? The answer is that chance enters into the story, but not a single, monolithic act of chance. Instead, a whole series of tiny chance steps, each one small enough to be a believable product of its predecessor, occurred one after the other in sequence. These small steps of chance are caused by genetic mutations, random changes - mistakes really - in the genetic material. They give rise to changes in the existing bodily structure. Most of these changes are deleterious and lead to death. A minority of them turn out to be slight improvements, leading to increased survival and reproduction. By this process of natural selection, those random changes that turn out to be beneficial eventually spread through the species and become the norm. The stage is now set for the next small change in the evolutionary process. After, say, a thousand of these small changes in series, each change providing the basis for the next, the end result has become, by a process of accumulation, far too complex to have come about in a single act of chance.

For instance, it is theoretically possible for an eye to spring into being, in a single lucky step, from nothing: from bare skin, let's say. It is theoretically possible in the sense that a recipe could be written out in the form of a large number of mutations. If all these mutations happened simultaneously, a complete eye could, indeed, spring from nothing. But although it is theoretically possible, it is in practice inconceivable. The quantity of luck involved is much too large. The "correct" recipe involves changes in a huge number of genes simultaneously. The correct recipe is one particular combination of changes out of trillions of equally probable combinations of chances. We can certainly rule out such a miraculous coincidence. But it *is* perfectly plausible that the modern eye could have sprung from something almost the same as the modern eye but not quite: a very slightly less elaborate eye. By the same argument, this slightly less elaborate eye sprang from a slightly less elaborate eye still, and so on. If you assume a *sufficiently large number of sufficiently small differences* between each evolutionary stage and its predecessor, you are bound to be able to derive a full, complex, working eye from bare skin. How many intermediate stages are we allowed to postulate? That depends on how much time we have to play with. Has there been enough time for eyes to evolve by little steps from nothing?

The fossils tell us that life has been evolving on Earth for more than 3,000 million years. It is almost impossible for the human mind to grasp such an immensity of time. We, naturally and mercifully, tend to see our own expected lifetime as a fairly long time, but we can't expect to live even one century. It is 2,000 years since Jesus lived, a time span long enough to blur the distinction between history and myth. Can you imagine a million such periods laid end to end? Suppose we wanted to write the whole history on a single long scroll. If we crammed all of Common Era history into one metre of scroll, how long would the pre-Common Era part of the scroll, back to the start of evolution, be? The answer is that the pre-Common Era part of the scroll would stretch from Milan to Moscow. Think of the implications of this for the quantity of evolutionary change that can be accommodated. All the domestic breeds of dogs - Pekingeses, poodles, spaniels, Saint Bernards, and Chihuahuas - have come from wolves in a time span measured in hundreds or at the most thousands of years: no more than two meters along the road from Milan to Moscow. Think of the quantity of change involved in going from a wolf to a Pekingese; now multiply that quantity of change by a million. When you look at it like that, it becomes easy to believe that an eye could have evolved from no eye by small degrees.

It remains necessary to satisfy ourselves that every one of the intermediates on the evolutionary route, say from bare skin to a modern eye, would have been favored by natural selection; would have been an improvement over its predecessor in the sequence or at least would have survived. It is no good proving to ourselves that there is theoretically a chain of almost perceptibly different intermediates leading to an eye if many of those intermediates would have died. It is sometimes argued that the parts of an eye have to be all there together or the eye won't work at all. Half an eye, the argument runs, is no better than no eye at all. You can't fly with half a wing; you can't hear with half an ear. Therefore there can't have been a series of step-by-step intermediates leading up to a modern eye, wing, or ear.

This type of argument is so naive that one can only wonder at the subconscious motives for wanting to believe it. It is obviously not true that half an eye is useless. Cataract sufferers who have had their lenses surgically removed cannot see very well without glasses, but they are still much better off than people with no eyes at all. Without a lens you can't focus a detailed image, but you can avoid bumping into obstacles and you could

detect the looming shadow of a predator.

As for the argument that you can't fly with only half a wing, it is disproved by large numbers of very successful gliding animals, including mammals of many different kinds, lizards, frogs, snakes, and squids. Many different kinds of tree-dwelling animals have flaps of skin between their joints that really are fractional wings. If you fall out of a tree, any skin flap or flattening of the body that increases your surface area can save your life. And, however small or large your flaps may be, there must always be a critical height such that, if you fall from a tree of that height, your life would have been saved by just a little bit more surface area. Then, when your descendants have evolved that extra surface area, their lives would be saved by just a bit more still if they fell from trees of a slightly greater height. And so on by insensibly graded steps until, hundreds of generations later, we arrive at full wings.

Eyes and wings cannot spring into existence in a single step. That would be like having the almost infinite luck to hit upon the combination number that opens a large bank vault. But if you spun the dials of the lock at random, and every time you got a little bit closer to the lucky number the vault door creaked open another chink, you would soon have the door open! Essentially, that is the secret of how evolution by natural selection achieves what once seemed impossible. Things that cannot plausibly be derived from very different predecessors *can* plausibly be derived from only slightly different predecessors. Provided only that there is a sufficiently long series of such slightly different predecessors, you can derive anything from anything else.

Evolution, then, is theoretically *capable* of doing the job that, once upon a time, seemed to be the prerogative of God. But is there any evidence that evolution actually has happened? The answer is yes; the evidence is overwhelming. Millions of fossils are found in exactly the places and at exactly the depths that we should expect if evolution had happened. Not a single fossil has ever been found in any place where the evolution theory would not have expected it, although this *could* very easily have happened: a fossil mammal in rocks so old that fishes have not yet arrived, for instance, would be enough to disprove the evolution theory.

The patterns of distribution of living animals and plants on the continents and islands of the world is exactly what would be expected if they had evolved from common ancestors by slow, gradual degrees. The patterns of resemblance among animals and plants is exactly what we should expect if some were close cousins, and others more distant cousins to each other. The fact that the genetic code is the same in all living creatures overwhelmingly suggests that all are descended from one single ancestor. The evidence for evolution is so compelling that the only way to save the creation theory is to assume that God deliberately planted enormous quantities of evidence to make it *look* as if evolution had happened. In other words, the fossils, the geographical distribution of animals, and so on, are all one gigantic confidence trick. Does anybody want to worship a God capable of such trickery? It is surely far more reverent, as well as more scientifically sensible, to take the evidence at face value. All living creatures are cousins of one another, descended from one remote ancestor that lived more than 3,000 million years ago.

The Argument from Design, then, has been destroyed as a reason for believing in a God. Are there any other arguments? Some people believe in God because of what appears to them to be an inner revelation. Such revelations are not always edifying but they undoubtedly feel real to the individual concerned. Many inhabitants of lunatic asylums have

an unshakable inner faith that they are Napoleon or, indeed, God himself. There is no doubting the power of such convictions for those that have them, but this is no reason for the rest of us to believe them. Indeed, since such beliefs are mutually contradictory, we can't believe them all.

There is a little more that needs to be said. Evolution by natural selection explains a lot, but it couldn't start from nothing. It couldn't have started until there was some kind of rudimentary reproduction and heredity. Modern heredity is based on the DNA code, which is itself too complicated to have sprung spontaneously into being by a single act of chance. This seems to mean that there must have been some earlier hereditary system, now disappeared, which was simple enough to have arisen by chance and the laws of chemistry and which provided the medium in which a primitive form of cumulative natural selection could get started. DNA was a later product of this earlier cumulative selection. Before this original kind of natural selection, there was a period when complex chemical compounds were built up from simpler ones and before that a period when the chemical elements were built up from simpler elements, following the well-understood laws of physics. Before that, everything was ultimately built up from pure hydrogen in the immediate aftermath of the big bang, which initiated the universe.

There is a temptation to argue that, although God may not be needed to explain the evolution of complex order once the universe, with its fundamental laws of physics, had begun, we do need a God to explain the origin of all things. This idea doesn't leave God with very much to do: just set off the big bang, then sit back and wait for everything to happen. The physical chemist Peter Atkins, in his beautifully written book *The Creation*, postulates a lazy God who strove to do as little as possible in order to initiate everything. Atkins explains how each step in the history of the universe followed, by simple physical law, from its predecessor. He thus pares down the amount of work that the lazy creator would need to do and eventually concludes that he would in fact have needed to do nothing at all!

The details of the early phase of the universe belong to the realm of physics, whereas I am a biologist, more concerned with the later phases of the evolution of complexity. For me, the important point is that, even if the physicist needs to postulate an irreducible minimum that had to be present in the beginning, in order for the universe to get started, that irreducible minimum is certainly extremely simple. By definition, explanations that build on simple premises are more plausible and more satisfying than explanations that have to postulate complex and statistically improbable beginnings. And you can't get much more complex than an Almighty God!

Preliminaries

Between 13 August 1995 and 26 August 1995 Steven Carr posted the transcript of a 1994 Channel-4 (U.K.) interview with biologist Richard Dawkins to the Usenet newsgroup alt.atheism.moderated. With Steven's permission, I have made the postings available here. I have combined Steven's multiple postings into one document, made some formatting changes, deleted Steven's comments, fixed typos, and changed some British spellings to American ones.

In my opinion, Dawkins was as provocative and clear in his statements as ever, and I cannot but agree with what he says. Not surprisingly, the series of postings generated a mass of crackpot attempts at rationalizations of the concept of God with science and the Universe. In spite of the moderation, the signal-to-noise ratio in alt.atheism.moderated quickly plummeted to zero.

Feedback: If you have questions or comments regarding the HTML formatting, please send them to me at krishna_kunchith@hotmail.com. If you have any questions about the interview or transcription, direct them at Steven Carr. If you have comments about the contents of the interview, mail Richard Dawkins at Oxford.

Enjoy.

Krishna.

Introduction

Channel 4 in the UK ran a half-hour series of interviews in 1994 called The Vision Thing. Various people with different beliefs were interviewed by Sheena McDonald, a respected TV journalist. The only atheist viewpoint was put by Richard Dawkins on 15 Aug. 1994.

The views expressed do not necessarily agree with mine. This is not just the usual disclaimer.

Note that throughout the interview Sheena McDonald had a half-smile on her face as if to say "Well, these are strange opinions but I suppose I'll have to give them a hearing". She was though, as always, scrupulously fair.

At the time of the interview Richard Dawkins was reader in zoology at the University of Oxford. He is now Professor of Public Understanding of Science at Oxford. He currently has 3 of the top 10 best selling science books in Britain.

Steven Carr.

Interview: Sheena McDonald and Richard Dawkins

McDonald's intro: Imagine no religion! Even non-believers recognize the shock value of John Lennon's lyric. A godless universe is still a shocking idea in most parts of the world. But one English zoologist crusades for his vision of a world of truth, a world without religion, which he says is the enemy of truth, a world which understands the true meaning of life. He's called himself a scientific zealot. In London I met Richard Dawkins.

McDonald: Richard Dawkins, you have a vision of the world---this world free of lies, not the little lies that we protect ourselves with, but what you would see as the big lie, which is that God or some omnipotent creator made and oversees the world. Now, a lot of people are looking for meaning in the world, a lot of them find it through faith. So what's attractive about your godless world, what's beautiful---why would anyone want to live in your world?

Dawkins: The world and the universe is an extremely beautiful place, and the more we understand about it the more beautiful does it appear. It is an immensely exciting experience to be born in the world, born in the universe, and

look around you and realize that before you die you have the opportunity of understanding an immense amount about that world and about that universe and about life and about why we're here. We have the opportunity of understanding far, far more than any of our predecessors ever. That is such an exciting possibility, it would be such a shame to blow it and end your life not having understood what there is to understand.
McDonald: Right, well, let's maximize this opportunity. Paint the world, describe the opportunity that too many of us---you will probably say most of us---are not exploiting to appreciate the world and to understand the world.
Dawkins: Well, suppose you look at an animal such as a human or a hedgehog or a bat, and you really want to understand how it works. The scientific way of understanding how it works would be to treat it rather as an engineer would treat a machine. So if an engineer was handed this television camera that engineer would get a screwdriver out, take it to bits, perhaps try to work out a circuit diagram and try to work out what this thing did, what it was good for, how it works, would explain the functioning of the whole machine in terms of the bits, in terms of the parts.
Then the engineer would probably want to know how it came to be where it was, what's the history of it---was it put together in a factory? Was it sort of suddenly just gelled together spontaneously? Now those are the sorts of questions that a scientist would ask about a bat or a hedgehog or a human, and we've got a long way to go, but a great deal of progress has been made. We really do understand a lot about how we and rats and pigeons work.
I've spoken only of the mechanism of a living thing. There's a whole other set of questions about the history of living things, because each living thing comes into the world through being born or hatched, so you have to ask, where did it get its structure from? It got it largely from its genes. Where do the genes come from? From the parents, the grand-parents, the great-grand parents. You go on back through the history, back through countless generations of history, through fish ancestors, through worm-like ancestors, through protozoa-like ancestors, to bacteria-like ancestors.
McDonald: But the end point of this process would simply be an understanding of the physical world.
Dawkins: What else is there?
McDonald: But to accept your vision, one has to reject what many people hold very dear and close, which is faith. Now, why is faith, why is religious faith incompatible with your vision?
Dawkins: Well, faith as I understand it---you wouldn't bother to use the word faith unless it was being contrasted with some other means of knowing something. So faith to me means knowing something just because you know it's true, rather than because you have seen any evidence that it's true.
McDonald: But if I say I believe in God, you cannot disprove the existence of God.
Dawkins: No, and the virtue of using evidence is precisely that we can come to an agreement about it. But if you listen to two people who are arguing about something, and they each of them have passionate faith that they're right, but they believe different things---they belong to different religions, different faiths, there is nothing they can do to settle their disagreement short of shooting each other, which is what they very often actually do.
McDonald: If religion is an obstacle to understanding what you're saying, why is it getting it wrong?
Dawkins: A creator who created the universe or set up the laws of physics so that life would evolve or who actually supervised the evolution of life, or anything like that, would have to be some sort of super-intelligence, some sort of mega-mind. That mega-mind would have had to be present right at the start of the universe. The whole message of evolution is that complexity and intelligence and all the things that would go with being a creative force come late, they come as a consequence of hundreds of millions of years of natural selection. There was no intelligence early on in the universe. Intelligence arose, it's

arisen here, maybe it's arisen on lots of other places in the universe. Maybe somewhere in some other galaxy there is a super-intelligence so colossal that from our point of view it would be a god. But it cannot have been the sort of God that we need to explain the origin of the universe, because it cannot have been there that early.

McDonald: So religion is peddling a fundamental untruth.

Dawkins: Well, I think it is yes.

McDonald: And there is no possibility of there being something beyond our knowing, beyond your ability as a scientist, zoologist, to [...]

Dawkins: No, that's quite different. I think there's every possibility that there might be something beyond our knowing. All I've said is that I don't think there is any intelligence or any creativity or any purposiveness before the first few hundred million years that the universe has been in existence. So I don't think it's helpful to equate that which we don't understand with God in any sense that is already understood in the existing religions.

The gods that are already understood in existing religions are all thoroughly documented. They do things like forgive sins and impregnate virgins, and they do all sorts of rather ordinary, mundane, human kinds of things. That has nothing whatever to do with the high-flown profound difficulties that science may yet face in understanding the deep problems of the universe.

McDonald: Now a lot of people find great comfort from religion. Not everybody is as you are---well-favored, handsome, wealthy, with a good job, happy family life. I mean, your life is good---not everybody's life is good, and religion brings them comfort.

Dawkins: There are all sorts of things that would be comforting. I expect an injection of morphine would be comforting---it might be more comforting, for all I know. But to say that something is comforting is not to say that it's true.

McDonald: You have rejected religion, and you have written about and posited your own answers to the fundamental questions of life, which are---very crudely, that we and hedgehogs and bats and trees and geckos are driven by genetic and non-genetic replicators. Now instantly I want to know, what does that mean?

Dawkins: Replicators are things that have copies of themselves made. It's a very, very powerful---its' hard to realize what a powerful thing it was when the first self-replicating entity came into the world. Nowadays the most important self-replicating entities we know are DNA molecules; the original ones probably weren't DNA molecules, but they did something similar. Once you've got self-replicating entities---things that make copies of themselves---you get a population of them.

McDonald: In that very raw description that makes us---what makes us us? We're no more than collections of inherited genes each fighting to make its way by the survival of the fittest.

Dawkins: Yes, if you ask me as a poet to say, how do I react to the idea of being a vehicle for DNA? It doesn't sound very romantic, does it? It doesn't sound the sort of vision of life that a poet would have; and I'm quite happy, quite ready to admit that when I'm not thinking about science I'm thinking in a very different way.

It is a very helpful insight to say we are vehicles for our DNA, we are hosts for DNA parasites which are our genes. Those are insights which help us to understand an aspect of life. But it's emotive to say, that's all there is to it, we might as well give up going to Shakespeare plays and give up listening to music and things, because that's got nothing to do with it. That's an entirely different subject.

McDonald: Let's talk about listening to music and going to Shakespeare plays. Now, you coined a word to describe all these various activities which are not genetically driven, and that word is 'meme' and again this is a replicating process.

Dawkins: Yes, there are cultural entities which replicate in something like the same way as DNA does. The spread of the habit of wearing a baseball hat backwards is something that has spread around the Western world like an

epidemic. It's like a smallpox epidemic. You could actually do epidemiology on the reverse baseball hat. It rises to a peak, plateaus and I sincerely hope it will die down soon.

McDonald: What about voting Labour?

Dawkins: Well, you can make---one can take more serious things like that. In a way, I'd rather not get into that, because I think there are better reasons for voting Labour than just slavish imitation of what other people do. Wearing a reverse baseball hat---as far as I know, there is no good reason for that. One does it because one sees one's friends do or, and one thinks it looks cool, and that's all. So that really is like a measles epidemic, it really does spread from brain to brain like a virus.

McDonald: So voting intentions you wouldn't put into that bracket. What about religious practices?

Dawkins: Well, that's a better example. It doesn't spread, on the whole, in a horizontal way, like a measles epidemic. It spreads in a vertical way down the generations. But that kind of thing, I think, spreads down the generations because children at a certain age are very vulnerable to suggestion. They tend to believe what they're told, and there are very good reasons for that. It is easy to see in a Darwinian explanation why children should be equipped with brains that believe what adults tell them. After all, they have to learn a language, and learn a lot else from adults. Why wouldn't they believe it if they're told that they have to pray in a certain way? But in particular---let's just rephrase that---if they're told that not only do they have to behave in such a way, but when they grow up it is their duty to pass on the same message to their children.

Now, once you've got that little recipe, that really is a recipe for passing on and on down the generations. It doesn't matter how silly the original instruction is, if you tell it with sufficient conviction to sufficiently young and gullible children such that when they grow up they will pass it on to their children, then it will pass on and it will pass on and it will spread and that could be sufficient explanation.

McDonald: But religion is a very successful meme. I mean, in your own structures the genes that survive---the ones with the most selfish and successful genes presumably have some merit. Now if religion is a meme which has survived over thousands and thousands of years, is it not possible that there is some intrinsic merit in that?

Dawkins: Yes, there is merit in it. If you ask the question, why does any replicating entity survive over the years and the generations, it is because it has merit. But merit to a replicator just means that it's good at replicating. The rabies virus has considerable merit, and the AIDS virus has enormous merit. These things spread very successfully, and natural selection has built into them extremely effective methods of spreading. In the case of the rabies virus it causes its victims to foam at the mouth, and the virus is actually spread in saliva. It causes them to bite and to become aggressive, so they tend to bite other animals, and the saliva gets into them and it gets passed on. This is a very, very successful virus. It has very considerable merit.

In a way the whole message of the meme and gene idea is that merit is defined as goodness at getting itself spread around, goodness at self-replication. That's of course very different from merit as we humans might judge it.

McDonald: You've chosen an analogy there for religion which a lot of them would find rather hurtful---that it's like an AIDS virus, like a rabies virus.

Dawkins: I think it's a very good analogy. I'm sorry if it's hurtful. I'm trying to explain why these things spread; and I think it's like a chain letter. It is the same kind of stick and carrot. It's not, probably, deliberately thought out.

I could write on a piece of paper "Make two copies of this paper and pass them to friends". I could give it to you. You would read it and make two copies and pass them, and they would make 2 copies and it becomes 4 copies, 8, 16 copies. Pretty soon the whole world would be knee-deep in paper. But of course there has

to be some sort of inducement, so I would have to add something like this "If you do not make 2 copies of this bit of paper and pass it on, you will have bad luck, or you will go to hell, or some dreadful misfortune will befall you".

I think if we start with a chain letter and then say, well, the chain letter principle is too simple in itself, but if we then sort of build upon the chain letter principle and look upon more and more sophisticated inducements to pass on the message, we shall have a successful explanation.

McDonald: But that's all it can be, I mean, sophisticated inducements or threats. I was only bothered that a successful meme may invoke something which has not yet been found in your universe by your methods.

Dawkins: The sophisticated inducements can include the B Minor Mass and the St. Matthew Passion. I mean, they're pretty good stuff. They're very sophisticated and very, very beautiful---stained glass windows, Chartres Cathedral, they work and no wonder they work. I mean they're beautifully done, beautifully crafted.

But I think what you're asking is, does the success of religion down the centuries imply that there must be some truth in its claims? I don't think that is necessary at all, because I think there are plenty of other good explanations which do a better job.

McDonald: Does it exasperate you that people find more pleasure and inspiration in Chartres or Beethoven or indeed great mosques than they do in the anatomy of a lizard?

Dawkins: No, not at all. I mean, I think that great artistic experiences---I don't want to downplay them in any way. I think they are very, very great experiences, and scientific understanding is on a par with them.

McDonald: And yet, these great artistic achievements have been impelled by untruths.

Dawkins: Just think how much greater they would have been if they had been impelled by truth.

McDonald: But can the anatomy of a lizard provoke a great choral symphony?

Dawkins: By calling it the anatomy of a lizard, you, as it were, play for laughs. But if you put it another way---let's say, does geological time or does the evolution of life on earth, could that be the inspiration for a great symphony? Well, of course, it could. It would be hard to imagine a more colossal inspiration for a great piece of music or poetry than 2,000 million years of slow, gradual evolutionary change.

McDonald: But ultimately, there's no point beyond the personal celebration of each life, as far as you're able to. We hope that we're not born into a famine queue in central Africa. But that's not sufficient for people. Maybe they want [...]

Dawkins: Look, it may not be [...]

McDonald: But tough, you say [...]

Dawkins:Tough, yes. I don't want to sound callous. I mean, even if I have nothing to offer, that doesn't matter, because that still doesn't mean that what anybody else has to offer therefore has to be true.

McDonald: Indeed, but you care about it.

Dawkins: Yes, I do want to offer something. I just wanted to give as a preamble the point that there may be a vacuum which is left. If religion goes, there may well be a vacuum in important ways in people's psychology, in people's happiness, and I don't claim to be able to fill that vacuum, and that is not what I want to claim to be able to do. I want to find out what's true.

Now, as for what I might have to offer, I've tried to convey the excitement, the exhilaration of getting as complete a picture of the world and the universe in which you live as possible. You have the power to make a pretty good model of the universe in which you live. It's going to be temporary, you're going to die, but it would be the best way you could spend your time in the universe, to understand why you're there and place as accurate model of the universe as you can inside your head. That's what I would like to encourage people to try to do.

I think it's an immensely fulfilling thing to do.

McDonald: And that will be a better world?

Dawkins: It will certainly be a truer world. I mean, people would have a truer view of the world. I think it would probably be a better world. I think people would be less ready to fight each other because so much of the motivation for fighting would have been removed. I think it would be a better world. It would be a better world in the sense that people would be more fulfilled in having a proper understanding of the world instead of a superstitious understanding.
McDonald: So here we are, in your truer world---except we're not, because for the reasons of juvenile gullibility you suggested the religion meme will continue to replicate itself around the world. For ever will it, or will we ever come to your world?
Dawkins: I suspect for a very long time. I don't know about for ever, whatever for ever is. I mean, I think religion has got an awful long time to go yet, certainly in some parts of the world. I find that a rather depressing prospect, but it is probably true.
McDonald: Isn't that to an extent because you've said yourself, what you have to say may not fill the vacuum which would be left if religion were discarded?
Dawkins: I feel no vacuum. I mean, I feel very happy, very fulfilled. I love my life and I love all sorts of aspects of it which have nothing to do with my science. So I don't have a vacuum. I don't feel cold and bleak. I don't think the world is a cold and bleak place. I think the world is a lovely and a friendly place and I enjoy being in it.
McDonald: Do you think about death?
Dawkins: Yes. I mean, it's something which is going to happen to all of us and [...]
McDonald: How do you prepare for death in a world where there isn't a god?
Dawkins: You prepare for it by facing up to the truth, which is that life is what we have and so we had better live our life to the full while we have it, because there is nothing after it. We are very lucky accidents or at least each one of us is---if we hadn't been here, someone else would have been. I take all this to reinforce my view that I am fantastically lucky to be here and so are you, and we ought to use our brief time in the sunlight to maximum effect by trying to understand things and get as full a vision of the world and life as our brains allow us to, which is pretty full.
McDonald: And that is the first duty, right, responsibility, pleasure of man and woman. Christians would say "love God, love your neighbor". You would say "try to understand".
Dawkins: Well, I wouldn't wish to downplay love your neighbor. It would be rather sad if we didn't do that. But, having agreed that we should love our neighbor and all the other things that are embraced by that wee phrase, I think that, yes, understand, understand is a pretty good commandment.

(End of interview)

Sheena McDonald's wrap-up to camera: Richard Dawkins celebrates life before death with infectious enthusiasm. He rejects life after death with---for many---uncomfortable enthusiasm. In doing so he shows the courage of a true zealot, to go on preaching in the face of continuing resistance to a godless universe. It remains to be seen whether the Dawkins meme, his vision of truth, will replicate with the success that the prophets, priests, popes and gurus have enjoyed.

[Miscellaneous | Krishna Kunchithapadam]

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When Religion Steps on Science's Turf
The Alleged Separation Between the Two Is Not So Tidy
by Richard Dawkins

The following article is from Free Inquiry magazine, Volume 18, Number 2.

A cowardly flabbiness of the intellect afflicts otherwise rational people confronted with long-established religions (though, significantly, not in the face of younger traditions such as Scientology or the Moonies). S. J. Gould, commenting in his Natural History column on the pope's attitude to evolution, is representative of a dominant strain of conciliatory thought, among believers and nonbelievers alike: "Science and religion are not in conflict, for their teachings occupy distinctly different domains ... I believe, with all my heart, in a respectful, even loving concordat [my emphasis] ...."

Well, what are these two distinctly different domains, these "Nonoverlapping Magisteria" that should snuggle up together in a respectful and loving concordat? Gould again: "The net of science covers the empirical universe: what is it made of (fact) and why does it work this way (theory). The net of religion extends over questions of moral meaning and value."

Who Owns Morals?
Would that it were that tidy. In a moment I'll look at what the pope actually says about evolution, and then at other claims of his church, to see if they really are so neatly distinct from the domain of science. First though, a brief aside on the claim that religion has some special expertise to offer us on moral questions. This is often blithely accepted even by the nonreligious, presumably in the course of a civilized "bending over backwards" to concede the best point your opponent has to offer - however weak that best point may be.

The question, "What is right and what is wrong?" is a genuinely difficult question that science certainly cannot answer. Given a moral premise or a priori moral belief, the important and rigorous discipline of secular moral philosophy can pursue scientific or logical modes of reasoning to point up hidden implications of such beliefs, and hidden inconsistencies between them. But the absolute moral premises themselves must come from elsewhere, presumably from unargued conviction. Or, it might be hoped, from religion - meaning some combination of authority, revelation, tradition, and scripture.

Unfortunately, the hope that religion might provide a bedrock, from which our otherwise sand-based morals can be derived, is a forlorn one. In practice, no civilized person uses Scripture as ultimate authority for moral reasoning. Instead, we pick and choose the nice bits of Scripture (like the Sermon on the Mount) and blithely ignore the nasty bits (like the obligation to stone adulteresses, execute apostates, and punish the grandchildren of offenders). The God of the Old Testament himself, with his pitilessly vengeful jealousy, his racism, sexism, and terrifying bloodlust, will not be adopted as a literal role model by anybody you or I would wish to know. Yes, of course it is unfair to judge the customs of an earlier era by the enlightened standards of our own. But that is precisely my point! Evidently, we have some alternative source of ultimate moral conviction that overrides Scripture when it suits us.

That alternative source seems to be some kind of liberal consensus of decency and natural justice that changes over historical time, frequently under the influence of secular reformists. Admittedly, that doesn't sound like bedrock. But in practice we, including the religious among us, give it higher priority than Scripture. In practice we more or less ignore Scripture, quoting it when it supports our liberal consensus, quietly forgetting it when it doesn't. And wherever that liberal consensus comes from, it is available to all of us, whether we are religious or not.

Similarly, great religious teachers like Jesus or Gautama Buddha may inspire us, by their good example, to adopt their personal moral convictions. But again we pick and choose among religious leaders, avoiding the bad examples of Jim Jones or Charles Manson, and we may choose good secular role models such as Jawaharlal Nehru or Nelson Mandela. Traditions too, however anciently followed, may be good or bad, and we use our secular judgment of decency and natural justice to decide which ones to follow, which to give up.

Religion on Science's Turf
But that discussion of moral values was a digression. I now turn to my main topic of evolution and whether the pope lives up to the ideal of keeping off the scientific grass. His "Message on Evolution to the Pontifical Academy of Sciences" begins with some casuistical doubletalk designed to reconcile what John Paul II is about to say with the previous, more equivocal pronouncements of Pius XII, whose acceptance of evolution was comparatively grudging and reluctant. Then the pope comes to the harder task of reconciling scientific evidence with "revelation."

Revelation teaches us that [man] was created in the image and likeness of God. ... if the human body takes its origin from pre-existent living matter, the spiritual soul is immediately created by God ... Consequently, theories of evolution which, in accordance with the philosophies inspiring them, consider the mind as emerging from the forces of living matter, or as a mere epiphenomenon of this matter, are incompatible with the truth about man. ... With man, then, we find ourselves in the presence of an ontological difference, an ontological leap, one could say.

To do the pope credit, at this point he recognizes the essential contradiction between the two positions he is attempting to reconcile: "However, does not the posing of such ontological discontinuity run counter to that physical continuity which seems to be the main thread of research into evolution in the field of physics and chemistry?"

Never fear. As so often in the past, obscurantism comes to the rescue:

Consideration of the method used in the various branches of knowledge makes it possible to reconcile two points of view which would seen irreconcilable. The sciences of observation describe and measure the multiple manifestations of life with increasing precision and correlate them with the time line. The moment of transition to the spiritual cannot be the object of this kind of observation, which nevertheless can discover at the experimental level a series of very valuable signs indicating what is specific to the human being.

In plain language, there came a moment in the evolution of hominids when God intervened and injected a human soul into a previously animal lineage. (When? A million years ago? Two million years ago? Between Homo erectus and Homo sapiens? Between "archaic" Homo sapiens and H. sapiens sapiens?) The sudden injection is necessary, of course, otherwise there would be no distinction upon which to base Catholic morality, which is speciesist to the core. You can kill adult animals for meat, but abortion and euthanasia are murder because human life is involved.

Catholicism's "net" is not limited to moral considerations, if only because Catholic morals have scientific implications. Catholic morality demands the presence of a great gulf between Homo sapiens and the rest of the animal kingdom. Such a gulf is fundamentally anti-evolutionary. The sudden injection of an immortal soul in the timeline is an anti-evolutionary intrusion into the domain of science.

More generally it is completely unrealistic to claim, as Gould and many others do, that religion keeps itself away from science's turf, restricting itself to morals and values. A universe with a supernatural presence would be a fundamentally and qualitatively different kind of universe from one without. The difference is, inescapably, a scientific difference. Religions make existence claims, and this means scientific claims.

The same is true of many of the major doctrines of the Roman Catholic Church. The Virgin Birth, the bodily Assumption of the Blessed Virgin Mary, the Resurrection of Jesus, the survival of our own souls after death: these are all claims of a clearly scientific nature. Either Jesus had a corporeal father or he didn't. This is not a question of "values" or "morals"; it is a question of sober fact. We may not have the evidence to answer it, but it is a scientific question, nevertheless. You may be sure that, if any evidence supporting the claim were discovered, the Vatican would not be reticent in promoting it.

Either Mary's body decayed when she died, or it was physically removed from this planet to Heaven. The official Roman Catholic doctrine of Assumption, promulgated as recently as 1950, implies that Heaven has a physical location and exists in the domain of physical reality - how else could the physical body of a woman go there? I am not, here, saying that the doctrine of the Assumption of the Virgin is necessarily false (although of course I think it is). I am simply rebutting the claim that it is outside the domain of science. On the contrary, the Assumption of the Virgin is transparently a scientific theory. So is the theory that our souls survive bodily death, and so are all stories of angelic visitations, Marian manifestations, and miracles of all types.

There is something dishonestly self-serving in the tactic of claiming that all religious beliefs are outside the domain of science. On the one hand, miracle stories and the promise of life after death are used to impress simple people, win converts, and swell congregations. It is precisely their scientific power that gives these stories their popular appeal. But at the same time it is considered below the belt to subject the same stories to the ordinary rigors of scientific criticism: these are religious matters and therefore outside the domain of science. But you cannot have it both ways. At least, religious theorists and apologists should not be allowed to get away with having it both ways. Unfortunately all too many of us, including nonreligious people, are unaccountably ready to let them.

I suppose it is gratifying to have the pope as an ally in the struggle against fundamentalist creationism. It is certainly amusing to see the rug pulled out from under the feet of Catholic creationists such as Michael Behe. Even so, given a choice between honest-to-goodness fundamentalism on the one hand, and the obscurantist, disingenuous doublethink of the Roman Catholic Church on the other, I know which I prefer.

Richard Dawkins, one of the world's leading evolutionary biologists, is Charles Simonyi Professor of Public Understanding of Science at Oxford University and Senior Editor of Free Inquiry.

The Likelihood of God
-- by Richard Dawkins
(source of excerpt unknown)

Index: Atheism and Awareness (Editorials)
Home to Positive Atheism
I suspect that most people have a residue of feeling that Darwinian evolution isn't quite big enough to explain everything about life. All I can say as a biologist is that the feeling disappears progressively the more you read about and study what is known about life and evolution.

I want to add one thing more. The more you understand the significance of evolution, the more you are pushed away from the agnostic position and towards atheism. Complex, statistically improbable things are by their nature more difficult to explain than simple, statistically probable things.

The great beauty of Darwin's theory of evolution is that it explains how complex, difficult to understand things could have arisen step by plausible step, from simple, easy to understand beginnings. We start our explanation from almost infinitely simple beginnings: pure hydrogen and a huge amount of energy. Our scientific, Darwinian explanations carry us through a series of well-understood gradual steps to all the spectacular beauty and complexity of life.

The alternative hypothesis, that it was all started by a supernatural creator, is not only superfluous, it is also highly improbable. It falls foul of the very argument that was originally put forward in its favour. This is because any God worthy of the name must have been a being of colossal intelligence, a supermind, an entity of extremely low probability -- a very improbable being indeed.

Even if the postulation of such an entity explained anything (and we don't need it to), it still wouldn't help because it raises a bigger mystery than it solves.

Science offers us an explanation of how complexity (the difficult) arose out of simplicity (the easy). The hypothesis of God offers no worthwhile explanation for anything, for it simply postulates what we are trying to explain. It postulates the difficult to explain, and leaves it at that. We cannot prove that there is no God, but we can safely conclude the He is very, very improbable indeed.

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On Debating Religion The "know-nothings", the "know-alls", and the "no-contests" Dec/94

A lecture by Richard Dawkins)

Richard Dawkins, well-known for his books on evolution, took part in a debate with the Archbishop of York, Dr John Habgood, on the existence of God at the Edinburgh science festival last Easter. [Easter '92 ed.] The science correspondent of The Observer reported that the "withering" Richard Dawkins clearly believed the "God should be spoken of in the same way as Father Christmas or the Tooth Fairy". He [the correspondent] overheard a gloomy cleric comment on the debate: "That was easy to sum up. Lions 10, Christians nil".

Religious people split into three main groups when faced with science. I shall label them the "know-nothings", the "know-alls", and the "no-contests". I suspect that Dr John Habgood, the Archbishop of York, probably belongs to the third of these groups, so I shall begin with them.

The "no-contests" are rightly reconciled to the fact that religion cannot compete with science on its own ground. They think there is no contest between science and religion, because they are simply about different things. the biblical account of the origin of the universe (the origin of life, the diversity of species, the origin of man) -- all those things are now known to be untrue.

The "no-contests" have no trouble with this: they regard it as naive in the extreme, almost bad taste to ask of a biblical story, is it true? True, they say, true? Of course it isn't true in any crude literal sense. Science and religion are not competing for the same territory. They are about different things. They are equally true, but in their different ways.

A favourite and thoroughly meaningless phrase is "religious dimension". You meet this in statements such as "science is all very well as far as it goes, but it leaves out the religious dimension".

The "know-nothings", or fundamentalists, are in one way more honest. They are true to history. They recognize that until recently one of religion's main functions was scientific: the explanation of existence, of the universe, of life. Historically, most religions have had or even been a cosmology and a biology. I suspect that today if you asked people to justify their belief in God, the dominant reason would be scientific. Most people, I believe, think that you need a God to explain the existence of the world, and especially the existence of life. They are wrong, but our education system is such that many people don't know it.

They are also true to history because you can't escape the scientific implications of religion. A universe with a God would like quite different from a universe without one. A physics, a biology where there is a God is bound to look different. So the most basic claims of religion are scientific. Religion is a scientific theory.

I am sometimes accused of arrogant intolerance in my treatment of creationists. Of course arrogance is an unpleasant characteristic, and I should hate to be thought arrogant in a general way. But there are limits! To get some idea of what it is like being a professional student of evolution, asked to have a serious debate with creationists, the following comparison is a fair one. Imagine yourself a classical scholar who has spent a lifetime studying Roman history in all its rich detail. Now somebody comes along, with a degree in marine engineering or mediaeval musicology, and tries to argue that the Romans never existed. Wouldn't you find it hard to suppress your impatience? And mightn't it look a bit like arrogance?

My third group, the "know-alls" (I unkindly name them that because I find their position patronising), think religion is good for people, perhaps good for society. Perhaps good because it consoles them in death or bereavement, perhaps because it provides a moral code.

Whether or not the actual beliefs of the religion are true doesn't matter. Maybe there isn't a God; we educated people know there is precious little evidence for one, let alone for ideas such as the Virgin birth or the Resurrection. but the uneducated masses need a God to keep them out of mischief or to comfort them in bereavement. The little matter of God's probably non-existence can be brushed to one side in the interest of greater social good. I need say not more about the "know-alls" because they wouldn't claim to have anything to contribute to scientific truth.

Is God a Superstring?

I shall now return to the "no-contests". The argument they mount is certainly worth serious examination, but I think that we shall find it has little more merit than those of the other groups.

God is not an old man with a white beard in the sky. Right then, what is God? And now come the weasel words. these are very variable. "God is not out there, he is in all of us." God is the ground of all being." "God is the essence of life." "God is the universe." "Don't you believe in the universe?" "Of course I believe in the universe." "Then you believe in God." "God is love, don't you believe in love?" "Right, then you believe in God?"

Modern physicists sometimes wax a bit mystical when they contemplate questions such as why the big bang happened when it did, why the laws of physics are these laws and not those laws, why the universe exists at all, and so on. Sometimes physicists may resort to saying that there is an inner core of mystery that we don't understand, and perhaps never can; and they may then say that perhaps this inner core of mystery is another name for God. Or in Stephen Hawkings's words, if we understand these things, we shall perhaps "know the mind of God."

The trouble is that God in this sophisticated, physicist's sense bears no resemblance to the God of the Bible or any other religion. If a physicist says God is another name for Planck's constant, or God is a superstring, we should take it as a picturesque metaphorical way of saying that the nature of superstrings or the value of Planck's constant is a profound mystery. It has obviously not the smallest connection with a being capable of forgiving sins, a being who might listen to prayers, who cares about whether or not the Sabbath begins at 5pm or 6pm, whether you wear a veil or have a bit of arm showing; and no connection whatever with a being capable of imposing a death penalty on His son to expiate the sins of the world before and after he was born.

The Fabulous Bible

The same is true of attempts to identify the big bang of modern cosmology with the myth of Genesis. There is only an utterly trivial resemblance between the sophisticated conceptions of modern physics, and the creation myths of the Babylonians and the Jews that we have inherited.

What do the "no-contests" say about those parts of scripture and religious teaching that once-upon-a-time would have been unquestioned religious and scientific truths; the creation of the world the creation of life, the various miracles of the Old and New Testaments,, survival after death, the Virgin Birth? These stories have become, in the hands of the "no-contests", little more than moral fables, the equivalent of Aesop of Hans Anderson. There is nothing wrong with that, but it is irritating that

they almost never admit this is what they are doing.
For instance, I recently heard the previous Chief Rabbi, Sir Immanuel Jacobovits, talking about the evils of racism. Racism is evil, and it deserves a better argument against it that the one he gave. Adam and Eve, he argued, were the ancestors of all human kind. Therefore, all human kind belongs to one race, the human race.
What are we going to make of an argument like that? The Chief Rabbi is an educated man, he obviously doesn't believe in Adam and Eve, so what exactly did he think he was saying?
He must have been using Adam and Eve as a fable, just as one might use the story of Jack the Giantkiller or Cinderella to illustrate some laudable moral homily.
I have the impression that clergymen are so used to treating the biblical stories as fables that they have forgotten the difference between fact and fiction. It's like the people who, when somebody dies on The Archers, write letters of condolence to the others.
Inheriting Religion
As a Darwinian, something strikes me when I look at religion. Religion shows a pattern of heredity which I think is similar to genetic heredity. The vast majority of people have an allegiance to one particular religion. there are hundreds of different religious sects, and every religious person is loyal to just one of those.
Out of all of the sects in the world, we notice an uncanny coincidence: the overwhelming majority just happen to choose the one that their parents belong to. Not the sect that has the best evidence in its favour, the best miracles, the best moral code, the best cathedral, the best stained glass, the best music: when it comes to choosing from the smorgasbord of available religions, their potential virtues seem to count for nothing, compared to the matter of heredity.
This is an unmistakable fact; nobody could seriously deny it. Yet people with full knowledge of the arbitrary nature of this heredity, somehow manage to go on believing in their religion, often with such fanaticism that they are prepared to murder people who follow a different one.
Truths about the cosmos are true all around the universe. They don't differ in Pakistan, Afghanistan, Poland, or Norway. Yet, we are apparently prepared to accept that the religion we adopt is a matter of an accident of geography.
If you ask people why they are convinced of the truth of their religion, they don't appeal to heredity. Put like that it sounds too obviously stupid. Nor do they appeal to evidence. There isn't any, and nowadays the better educated admit it. No, they appeal to faith. Faith is the great cop-out, the great excuse to evade the need to think and evaluate evidence. Faith is belief in spite of, even perhaps because of, the lack of evidence. The worst thing is that the rest of us are supposed to respect it: to treat it with kid gloves.
If a slaughterman doesn't comply with the law in respect of cruelty to animals, he is rightly prosecuted and punished. but if he complains that his cruel practices are necessitated by religious faith, we back off apologetically and allow him to get on with it. Any other position that someone takes up can expect to be defended with reasoned argument. Faith is allowed not to justify itself by argument. Faith must be respected; and if you don't respect it, you are accused of violating human rights.
Even those with no faith have been brainwashed into respecting the faith of others. When so-called Muslim community leaders go on the radio and advocate the killing of Salman Rushdie, they are clearly committing incitement to murder--a crime for which they would ordinarily be prosecuted and possibly imprisoned. But are they arrested? They are not, because our secular society "respects" their faith, and sympathises with the deep "hurt" and "insult" to it.
Well I don't. I will respect your views if you can justify them. but if you justify your views only by saying you have faith in them, I shall not

respect them.

Improbabilities

I want to end by returning to science. It is often said, mainly by the "no-contests", that although there is no positive evidence for the existence of God, nor is there evidence against his existence. So it is best to keep an open mind and be agnostic.

At first sight that seems an unassailable position, at least in the weak sense of Pascal's wager. But on second thoughts it seems a cop-out, because the same could be said of Father Christmas and tooth fairies. There may be fairies at the bottom of the garden. There is no evidence for it, but you can't prove that there aren't any, so shouldn't we be agnostic with respect to fairies?

The trouble with the agnostic argument is that it can be applied to anything. There is an infinite number of hypothetical beliefs we could hold which we can't positively disprove. On the whole, people don't believe in most of them, such as fairies, unicorns, dragons, Father Christmas, and so on. But on the whole they do believe in a creator God, together with whatever particular baggage goes with the religion of their parents.

I suspect the reason is that most people, though not belonging to the "know-nothing" party, nevertheless have a residue of feeling that Darwinian evolution isn't quite big enough to explain everything about life. All I can say as a biologist is that the feeling disappears progressively the more you read about and study what is known about life and evolution.

I want to add one thing more. The more you understand the significance of evolution, the more you are pushed away from the agnostic position and towards atheism. Complex, statistically improbable things are by their nature more difficult to explain than simple, statistically probable things.

The great beauty of Darwin's theory of evolution is that it explains how complex, difficult to understand things could have arisen step by plausible step, from simple, easy to understand beginnings. We start our explanation from almost infinitely simple beginnings: pure hydrogen and a huge amount of energy. Our scientific, Darwinian explanations carry us through a series of well-understood gradual steps to all the spectacular beauty and complexity of life.

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This was a lecture by Richard Dawkins extracted from The Nullifidian (Dec 94)

Viruses of the Mind
Richard Dawkins

1991

> The haven all memes depend on reaching is the human mind, but a human mind is itself an artifact created when memes restructure a human brain in order to make it a better habitat for memes. The avenues for entry and departure are modified to suit local conditions, and strengthened by various artificial devices that enhance fidelity and prolixity of replication: native Chinese minds differ dramatically from native French minds, and literate minds differ from illiterate minds. What memes provide in return to the organisms in which they reside is an incalculable store of advantages --- with some Trojan horses thrown in for good measure. . .
>
> Daniel Dennett, *Consciousness Explained*

1 Duplication Fodder

A beautiful child close to me, six and the apple of her father's eye, believes that Thomas the Tank Engine really exists. She believes in Father Christmas, and when she grows up her ambition is to be a tooth fairy. She and her school-friends believe the solemn word of respected adults that tooth fairies and Father Christmas really exist. This little girl is of an age to believe whatever you tell her. If you tell her about witches changing princes into frogs she will believe you. If you tell her that bad children roast forever in hell she will have nightmares. I have just discovered that without her father's consent this sweet, trusting, gullible six-year-old is being sent, for weekly instruction, to a Roman Catholic nun. What chance has she?

A human child is shaped by evolution to soak up the culture of her people. Most obviously, she learns the essentials of their language in a matter of months. A large dictionary of words to speak, an encyclopedia of information to speak about, complicated syntactic and semantic rules to order the speaking, are all transferred from older brains into hers well before she reaches half her adult size. When you are pre-programmed to absorb useful information at a high rate, it is hard to shut out pernicious or damaging information at the same time. With so many mindbytes to be downloaded, so many mental codons to be replicated, it is no wonder that child brains are gullible, open to almost any suggestion, vulnerable to subversion, easy prey to Moonies, Scientologists and nuns. Like immune-deficient patients, children are wide open to mental infections that adults might brush off without effort.

DNA, too, includes parasitic code. Cellular machinery is extremely good at copying DNA. Where DNA is concerned, it seems to have an eagerness to copy, seems eager to be copied. The cell nucleus is a paradise for DNA, humming with sophisticated, fast, and accurate duplicating machinery.

Cellular machinery is so friendly towards DNA duplication that it is small wonder cells play host to DNA parasites --- viruses, viroids, plasmids and a riff-raff of other genetic fellow travelers. Parasitic DNA even gets itself spliced seamlessly into the chromosomes themselves. ``Jumping genes'' and stretches of ``selfish DNA'' cut or copy themselves out of chromosomes and paste themselves in elsewhere. Deadly oncogenes are almost impossible to distinguish from the legitimate genes

between which they are spliced. In evolutionary time, there is probably a continual traffic from ``straight'' genes to ``outlaw,'' and back again (Dawkins, 1982). DNA is just DNA. The only thing that distinguishes viral DNA from host DNA is its expected method of passing into future generations. ``Legitimate'' host DNA is just DNA that aspires to pass into the next generation via the orthodox route of sperm or egg. ``Outlaw'' or parasitic DNA is just DNA that looks to a quicker, less cooperative route to the future, via a squeezed droplet or a smear of blood, rather than via a sperm or egg.

For data on a floppy disc, a computer is a humming paradise just as cell nuclei hum with eagerness to duplicate DNA. Computers and their associated disc and tape readers are designed with high fidelity in mind. As with DNA molecules, magnetized bytes don't literally ``want'' to be faithfully copied. Nevertheless, you can write a computer program that takes steps to duplicate itself. Not just duplicate itself within one computer but spread itself to other computers. Computers are so good at copying bytes, and so good at faithfully obeying the instructions contained in those bytes, that they are sitting ducks to self-replicating programs: wide open to subversion by software parasites. Any cynic familiar with the theory of selfish genes and memes would have known that modern personal computers, with their promiscuous traffic of floppy discs and e-mail links, were just asking for trouble. The only surprising thing about the current epidemic of computer viruses is that it has been so long in coming.

2 Computer Viruses: a Model for an Informational Epidemiology

Computer viruses are pieces of code that graft themselves into existing, legitimate programs and subvert the normal actions of those programs. They may travel on exchanged floppy disks, or over networks. They are technically distinguished from ``worms'' which are whole programs in their own right, usually traveling over networks. Rather different are ``Trojan horses,'' a third category of destructive programs, which are not in themselves self-replicating but rely on humans to replicate them because of their pornographic or otherwise appealing content. Both viruses and worms are programs that actually say, in computer language, ``Duplicate me.'' Both may do other things that make their presence felt and perhaps satisfy the hole-in-corner vanity of their authors. These side-effects may be ``humorous'' (like the virus that makes the Macintosh's built-in loudspeaker enunciate the words ``Don't panic,'' with predictably opposite effect); malicious (like the numerous IBM viruses that erase the hard disk after a sniggering screen-announcement of the impending disaster); political (like the Spanish Telecom and Beijing viruses that protest about telephone costs and massacred students respectively); or simply inadvertent (the programmer is incompetent to handle the low-level system calls required to write an effective virus or worm). The famous Internet Worm, which paralyzed much of the computing power of the United States on November 2, 1988, was not intended (very) maliciously but got out of control and, within 24 hours, had clogged around 6,000 computer memories with exponentially multiplying copies of itself.

``Memes now spread around the world at the speed of light, and replicate at rates that make even fruit flies and yeast cells look glacial in comparison. They leap promiscuously from vehicle to vehicle, and from medium to medium, and are proving to be virtually unquarantinable'' (Dennett 1990, p.131). Viruses aren't limited to electronic media such as disks and data lines. On its way from one computer to another, a virus may pass through printing ink, light rays in a human lens, optic nerve impulses and finger muscle contractions. A computer fanciers' magazine that printed the text of a virus program for the interest of its readers has been widely condemned. Indeed, such is the appeal of the virus idea to a certain kind of puerile mentality (the masculine gender is used

advisedly), that publication of any kind of ``how to'' information on designing virus programs is rightly seen as an irresponsible act.

I am not going to publish any virus code. But there are certain tricks of effective virus design that are sufficiently well known, even obvious, that it will do no harm to mention them, as I need to do to develop my theme. They all stem from the virus's need to evade detection while it is spreading.

A virus that clones itself too prolifically within one computer will soon be detected because the symptoms of clogging will become too obvious to ignore. For this reason many virus programs check, before infecting a system, to make sure that they are not already on that system. Incidentally, this opens the way for a defense against viruses that is analogous to immunization. In the days before a specific anti-virus program was available, I myself responded to an early infection of my own hard disk by means of a crude ``vaccination.'' Instead of deleting the virus that I had detected, I simply disabled its coded instructions, leaving the ``shell'' of the virus with its characteristic external ``signature'' intact. In theory, subsequent members of the same virus species that arrived in my system should have recognized the signature of their own kind and refrained from trying to double-infect. I don't know whether this immunization really worked, but in those days it probably was worth while ``gutting'' a virus and leaving a shell like this, rather than simply removing it lock, stock and barrel. Nowadays it is better to hand the problem over to one of the professionally written anti-virus programs.

A virus that is too virulent will be rapidly detected and scotched. A virus that instantly and catastrophically sabotages every computer in which it finds itself will not find itself in many computers. It may have a most amusing effect on one computer ---- erase an entire doctoral thesis or something equally side-splitting --- but it won't spread as an epidemic.

Some viruses, therefore, are designed to have an effect that is small enough to be difficult to detect, but which may nevertheless be extremely damaging. There is one type, which, instead of erasing disk sectors wholesale, attacks only spreadsheets, making a few random changes in the (usually financial) quantities entered in the rows and columns. Other viruses evade detection by being triggered probabilistically, for example erasing only one in 16 of the hard disks infected. Yet other viruses employ the time-bomb principle. Most modern computers are ``aware'' of the date, and viruses have been triggered to manifest themselves all around the world, on a particular date such as Friday 13th or April Fool's Day. From the parasitic point of view, it doesn't matter how catastrophic the eventual attack is, provided the virus has had plenty of opportunity to spread first (a disturbing analogy to the Medawar/Williams theory of ageing: we are the victims of lethal and sub-lethal genes that mature only after we have had plenty of time to reproduce (Williams, 1957)). In defense, some large companies go so far as to set aside one ``miner's canary'' among their fleet of computers, and advance its internal calendar a week so that any time-bomb viruses will reveal themselves prematurely before the big day.

Again predictably, the epidemic of computer viruses has triggered an arms race. Anti-viral software is doing a roaring trade. These antidote programs -- ``Interferon,'' ``Vaccine,'' ``Gatekeeper'' and others --- employ a diverse armory of tricks. Some are written with specific, known and named viruses in mind. Others intercept any attempt to meddle with sensitive system areas of memory and warn the user.

The virus principle could, in theory, be used for non-malicious, even beneficial purposes. Thimbleby (1991) coins the phrase ``liveware'' for his already-implemented use of the infection principle for keeping multiple copies of databases up to date. Every time a disk containing the database is

plugged into a computer, it looks to see whether there is already another copy present on the local hard disk. If there is, each copy is updated in the light of the other. So, with a bit of luck, it doesn't matter which member of a circle of colleagues enters, say, a new bibliographical citation on his personal disk. His newly entered information will readily infect the disks of his colleagues (because the colleagues promiscuously insert their disks into one another's computers) and will spread like an epidemic around the circle. Thimbleby's liveware is not entirely virus-like: it could not spread to just anybody's computer and do damage. It spreads data only to already-existing copies of its own database; and you will not be infected by liveware unless you positively opt for infection.

Incidentally, Thimbleby, who is much concerned with the virus menace, points out that you can gain some protection by using computer systems that other people don't use. The usual justification for purchasing today's numerically dominant computer is simply and solely that it *is* numerically dominant. Almost every knowledgeable person agrees that, in terms of quality and especially user-friendliness, the rival, minority system is superior. Nevertheless, ubiquity is held to be good in itself, sufficient to outweigh sheer quality. Buy the same (albeit inferior) computer as your colleagues, the argument goes, and you'll be able to benefit from shared software, and from a generally large circulation of available software. The irony is that, with the advent of the virus plague, ``benefit'' is not all that you are likely to get. Not only should we all be very hesitant before we accept a disk from a colleague. We should also be aware that, if we join a large community of users of a particular make of computer, we are also joining a large community of viruses --- even, it turns out, *disproportionately* larger.

Returning to possible uses of viruses for positive purposes, there are proposals to exploit the ``poacher turned gamekeeper'' principle, and ``set a thief to catch a thief.'' A simple way would be to take any of the existing anti-viral programs and load it, as a ``warhead,'' into a harmless self-replicating virus. From a ``public health'' point of view, a spreading epidemic of anti-viral software could be especially beneficial because the computers most vulnerable to malicious viruses --- those whose owners are promiscuous in the exchange of pirated programs --- will also be most vulnerable to infection by the healing anti-virus. A more penetrating anti-virus might --- as in the immune system --- ``learn'' or ``evolve'' an improved capacity to attack whatever viruses it encountered.

I can imagine other uses of the computer virus principle which, if not exactly altruistic, are at least constructive enough to escape the charge of pure vandalism. A computer company might wish to do market research on the habits of its customers, with a view to improving the design of future products. Do users like to choose files by pictorial icon, or do they opt to display them by textual name only? How deeply do people nest folders (directories) within one another? Do people settle down for a long session with only one program, say a word processors, or are they constantly switching back and forth, say between writing and drawing programs? Do people succeed in moving the mouse pointer straight to the target, or do they meander around in time-wasting hunting movements that could be rectified by a change in design?

The company could send out a questionnaire asking all these questions, but the customers that replied would be a biased sample and, in any case, their own assessment of their computer-using behavior might be inaccurate. A better solution would be a market-research computer program. Customers would be asked to load this program into their system where it would unobtrusively sit, quietly monitoring and tallying key-presses and mouse movements. At the end of a year, the customer would be asked to send in the disk file containing all the tallyings of the market-research program. But again, most people would not bother to cooperate and some might see it as an invasion of privacy and of their disk space.

The perfect solution, from the company's point of view, would be a virus. Like any other virus, it would be self-replicating and secretive. But it would not be destructive or facetious like an ordinary virus. Along with its self-replicating booster it would contain a market-research warhead. The virus would be released surreptitiously into the community of computer users. Just like an ordinary virus it would spread around, as people passed floppy disks and e-mail around the community. As the virus spread from computer to computer, it would build up statistics on users behavior, monitored secretly from deep within a succession of systems. Every now and again, a copy of the viruses would happen to find its way, by normal epidemic traffic, back into one of the company's own computers. There it would be debriefed and its data collated with data from other copies of the virus that had come ``home."

Looking into the future, it is not fanciful to imagine a time when viruses, both bad and good, have become so ubiquitous that we could speak of an ecological community of viruses and legitimate programs coexisting in the silicosphere. At present, software is advertised as, say, ``Compatible with System 7." In the future, products may be advertised as ``Compatible with all viruses registered in the 1998 World Virus Census; immune to all listed virulent viruses; takes full advantage of the facilities offered by the following benign viruses if present..." Word-processing software, say, may hand over particular functions, such as word-counting and string-searches, to friendly viruses burrowing autonomously through the text.

Looking even further into the future, whole integrated software systems might grow, not by design, but by something like the growth of an ecological community such as a tropical rain-forest. Gangs of mutually compatible viruses might grow up, in the same way as genomes can be regarded as gangs of mutually compatible genes (Dawkins, 1982). Indeed, I have even suggested that our genomes should be regarded as gigantic colonies of viruses (Dawkins, 1976). Genes cooperate with one another in genomes because natural selection has favored those genes that prosper in the presence of the other genes that happen to be common in the gene pool. Different gene pools may evolve towards different combinations of mutually compatible genes. I envisage a time when, in the same kind of way, computer viruses may evolve towards compatibility with other viruses, to form communities or gangs. But then again, perhaps not! At any rate, I find the speculation more alarming than exciting.

At present, computer viruses don't strictly evolve. They are invented by human programmers, and if they evolve they do so in the same weak sense as cars or aeroplanes evolve. Designers derive this year's car as a slight modification of last year's car, and then may, more or less consciously, continue a trend of the last few years --- further flattening of the radiator grill or whatever it may be. Computer virus designers dream up ever more devious tricks for outwitting the programmers of anti-virus software. But computer viruses don't --- so far --- mutate and evolve by true natural selection. They may do so in the future. Whether they evolve by natural selection, or whether their evolution is steered by human designers, may not make much difference to their eventual performance. By either kind of evolution, we expect them to become better at concealment, and we expect them to become subtly compatible with other viruses that are at the same time prospering in the computer community.

DNA viruses and computer viruses spread for the same reason: an environment exists in which there is machinery well set up to duplicate and spread them around and to obey the instructions that the viruses embody. These two environments are, respectively, the environment of cellular physiology and the environment provided by a large community of computers and data-handling machinery. Are there any other environments like these, any other humming paradises of replication?

3 The Infected Mind

I have already alluded to the programmed-in gullibility of a child, so useful for learning language and traditional wisdom, and so easily subverted by nuns, Moonies and their ilk. More generally, we all exchange information with one another. We don't exactly plug floppy disks into slots in one another's skulls, but we exchange sentences, both through our ears and through our eyes. We notice each other's styles of moving and dressing and are influenced. We take in advertising jingles, and are presumably persuaded by them, otherwise hard-headed businessmen would not spend so much money polluting their air with them.

Think about the two qualities that a virus, or any sort of parasitic replicator, demands of a friendly medium,. the two qualities that make cellular machinery so friendly towards parasitic DNA, and that make computers so friendly towards computer viruses. These qualities are, firstly, a readiness to replicate information accurately, perhaps with some mistakes that are subsequently reproduced accurately; and, secondly, a readiness to obey instructions encoded in the information so replicated.

Cellular machinery and electronic computers excel in both these virus-friendly qualities. How do human brains match up? As faithful duplicators, they are certainly less perfect than either cells or electronic computers. Nevertheless, they are still pretty good, perhaps about as faithful as an RNA virus, though not as good as DNA with all its elaborate proofreading measures against textual degradation. Evidence of the fidelity of brains, especially child brains, as data duplicators is provided by language itself. Shaw's Professor Higgins was able by ear alone to place Londoners in the street where they grew up. Fiction is not evidence for anything, but everyone knows that Higgins's fictional skill is only an exaggeration of something we can all down. Any American can tell Deep South from Mid West, New England from Hillbilly. Any New Yorker can tell Bronx from Brooklyn. Equivalent claims could be substantiated for any country. What this phenomenon means is that human brains are capable of pretty accurate copying (otherwise the accents of, say, Newcastle would not be stable enough to be recognized) but with some mistakes (otherwise pronunciation would not evolve, and all speakers of a language would inherit identically the same accents from their remote ancestors). Language evolves, because it has both the great stability and the slight changeability that are prerequisites for any evolving system.

The second requirement of a virus-friendly environment --- that it should obey a program of coded instructions --- is again only quantitatively less true for brains than for cells or computers. We sometimes obey orders from one another, but also we sometimes don't. Nevertheless, it is a telling fact that, the world over, the vast majority of children follow the religion of their parents rather than any of the other available religions. Instructions to genuflect, to bow towards Mecca, to nod one's head rhythmically towards the wall, to shake like a maniac, to ``speak in tongues'' --- the list of such arbitrary and pointless motor patterns offered by religion alone is extensive --- are obeyed, if not slavishly, at least with some reasonably high statistical probability.

Less portentously, and again especially prominent in children, the ``craze'' is a striking example of behavior that owes more to epidemiology than to rational choice. Yo-yos, hula hoops and pogo sticks, with their associated behavioral fixed actions, sweep through schools, and more sporadically leap from school to school, in patterns that differ from a measles epidemic in no serious particular. Ten years ago, you could have traveled thousands of miles through the United States and never seen a baseball cap turned back to front. Today, the reverse baseball cap is ubiquitous. I do not know what the pattern of geographical spread of the reverse baseball cap precisely was, but epidemiology is certainly among the professions primarily qualified to study it. We don't have to get into arguments about ``determinism''; we don't have to claim that children are compelled to imitate their

fellows' hat fashions. It is enough that their hat-wearing behavior, as a matter of fact, *is* statistically affected by the hat-wearing behavior of their fellows.

Trivial though they are, crazes provide us with yet more circumstantial evidence that human minds, especially perhaps juvenile ones, have the qualities that we have singled out as desirable for an informational parasite. At the very least the mind is a plausible *candidate* for infection by something like a computer virus, even if it is not quite such a parasite's dream-environment as a cell nucleus or an electronic computer.

It is intriguing to wonder what it might feel like, from the inside, if one's mind were the victim of a ``virus.'' This might be a deliberately designed parasite, like a present-day computer virus. Or it might be an inadvertently mutated and unconsciously evolved parasite. Either way, especially if the evolved parasite was the memic descendant of a long line of successful ancestors, we are entitled to expect the typical ``mind virus'' to be pretty good at its job of getting itself successfully replicated.

Progressive evolution of more effective mind-parasites will have two aspects. New ``mutants'' (either random or designed by humans) that are better at spreading will become more numerous. And there will be a ganging up of ideas that flourish in one another's presence, ideas that mutually support one another just as genes do and as I have speculated computer viruses may one day do. We expect that replicators will go around together from brain to brain in mutually compatible gangs. These gangs will come to constitute a package, which may be sufficiently stable to deserve a collective name such as Roman Catholicism or Voodoo. It doesn't too much matter whether we analogize the whole package to a single virus, to each one of the component parts to a single virus. The analogy is not that precise anyway, just as the distinction between a computer virus and a computer worm is nothing to get worked up about. What matters is that minds are friendly environments to parasitic, self-replicating ideas or information, and that minds are typically massively infected.

Like computer viruses, successful mind viruses will tend to be hard for their victims to detect. If you are the victim of one, the chances are that you won't know it, and may even vigorously deny it. Accepting that a virus might be difficult to detect in your own mind, what tell-tale signs might you look out for? I shall answer by imaging how a medical textbook might describe the typical symptoms of a sufferer (arbitrarily assumed to be male).

1. The patient typically finds himself impelled by some deep, inner conviction that something is true, or right, or virtuous: a conviction that doesn't seem to owe anything to evidence or reason, but which, nevertheless, he feels as totally compelling and convincing. We doctors refer to such a belief as ``faith.''

2. Patients typically make a positive virtue of faith's being strong and unshakable, *in spite of* not being based upon evidence. Indeed, they may fell that the less evidence there is, the more virtuous the belief (see below).

This paradoxical idea that lack of evidence is a positive virtue where faith is concerned has something of the quality of a program that is self-sustaining, because it is self-referential (see the chapter ``On Viral Sentences and Self-Replicating Structures'' in Hofstadter, 1985). Once the proposition is believed, it automatically undermines opposition to itself. The ``lack of evidence is a virtue'' idea could be an admirable sidekick, ganging up with faith itself in a clique of mutually supportive viral programs.

3. A related symptom, which a faith-sufferer may also present, is the conviction that ``mystery,'' *per*

se, is a good thing. It is not a virtue to solve mysteries. Rather we should enjoy them, even revel in their insolubility.

Any impulse to solve mysteries could be serious inimical to the spread of a mind virus. It would not, therefore, be surprising if the idea that ``mysteries are better not solved" was a favored member of a mutually supporting gang of viruses. Take the ``Mystery of Transubstantiation." It is easy and non-mysterious to believe that in some symbolic or metaphorical sense the eucharistic wine turns into the blood of Christ. The Roman Catholic doctrine of transubstantiation, however, claims far more. The ``whole substance" of the wine is converted into the blood of Christ; the appearance of wine that remains is ``merely accidental," ``inhering in no substance" (Kenny, 1986, p. 72). Transubstantiation is colloquially taught as meaning that the wine ``literally" turns into the blood of Christ. Whether in its obfuscatory Aristotelian or its franker colloquial form, the claim of transubstantiation can be made only if we do serious violence to the normal meanings of words like ``substance" and ``literally." Redefining words is not a sin, but, if we use words like ``whole substance" and ``literally" for this case, what word are we going to use when we really and truly *want* to say that something did actually happen? As Anthony Kenny observed of his own puzzlement as a young seminarian, ``For all I could tell, my typewriter might be Benjamin Disraeli transubstantiated...."

Roman Catholics, whose belief in infallible authority compels them to accept that wine becomes physically transformed into blood despite all appearances, refer to the ``mystery" of transubstantiation. Calling it a mystery makes everything OK, you see. At least, it works for a mind well prepared by background infection. Exactly the same trick is performed in the ``mystery" of the Trinity. Mysteries are not meant to be solved, they are meant to strike awe. The ``mystery is a virtue" idea comes to the aid of the Catholic, who would otherwise find intolerable the obligation to believe the obvious nonsense of the transubstantiation and the ``three-in-one." Again, the belief that ``mystery is a virtue" has a self-referential ring. As Hofstadter might put it, the very mysteriousness of the belief moves the believer to perpetuate the mystery.

An extreme symptom of ``mystery is a virtue" infection is Tertullian's ``*Certum est quia impossibile est*" (It is certain because it is impossible"). That way madness lies. One is tempted to quote Lewis Carroll's White Queen, who, in response to Alice's ``One can't believe impossible things" retorted ``I daresay you haven't had much practice... When I was your age, I always did it for half-an-hour a day. Why, sometimes I've believed as many as six impossible things before breakfast." Or Douglas Adam's Electric Monk, a labor-saving device programmed to do your believing for you, which was capable of ``believing things they'd have difficulty believing in Salt Lake City" and which, at the moment of being introduced to the reader, believed, contrary to all the evidence, that everything in the world was a uniform shade of pink. But White Queens and Electric Monks become less funny when you realize that these virtuoso believers are indistinguishable from revered theologians in real life. ``It is by all means to be believed, because it is absurd" (Tertullian again). Sir Thomas Browne (1635) quotes Tertullian with approval, and goes further: ``Methinks there be not impossibilities enough in religion for an active faith." And ``I desire to exercise my faith in the difficultest point; for to credit ordinary and visible objects is not faith, but perswasion [sic]."

I have the feeling that something more interesting is going on here than just plain insanity or surrealist nonsense, something akin to the admiration we feel when we watch a ten-ball juggler on a tightrope. It is as though the faithful gain prestige through managing to believe even more impossible things than their rivals succeed in believing. Are these people testing --- exercising --- their believing muscles, training themselves to believe impossible things so that they can take in their stride the merely improbable things that they are ordinarily called upon to believe?

While I was writing this, the *Guardian* (July 29, 1991) fortuitously carried a beautiful example. It came in an interview with a rabbi undertaking the bizarre task of vetting the kosher-purity of food products right back to the ultimate origins of their minutest ingredients. He was currently agonizing over whether to go all the way to China to scrutinize the menthol that goes into cough sweets. ``Have you ever tried checking Chinese menthol... it was extremely difficult, especially since the first letter we sent received the reply in best Chinese English, `The product contains no kosher'... China has only recently started opening up to kosher investigators. The menthol should be OK, but you can never be absolutely sure unless you visit." These kosher investigators run a telephone hot-line on which up-to-the-minute red-alerts of suspicion are recorded against chocolate bars and cod-liver oil. The rabbi sighs that the green-inspired trend away from artificial colors and flavors ``makes life miserable in the kosher field because you have to follow all these things back." When the interviewer asks him why he bothers with this obviously pointless exercise, he makes it very clear that the point is precisely that there *is* no point:

> That most of the Kashrut laws are divine ordinances without reason given is 100 per cent the point. It is very easy not to murder people. Very easy. It is a little bit harder not to steal because one is tempted occasionally. So that is no great proof that I believe in God or am fulfilling His will. But, if He tells me not to have a cup of coffee with milk in it with my mincemeat and peaces at lunchtime, that is a test. The only reason I am doing that is because I have been told to so do. It is something difficult.

Helena Cronin has suggested to me that there may be an analogy here to Zahavi's handicap theory of sexual selection and the evolution of signals (Zahavi, 1975). Long unfashionable, even ridiculed (Dawkins, 1976), Zahavi's theory has recently been cleverly rehabilitated (Grafen, 1990 a, b) and is now taken seriously by evolutionary biologists (Dawkins, 1989). Zahavi suggests that peacocks, for instance, evolve their absurdly burdensome fans with their ridiculously conspicuous (to predators) colors, precisely *because* they are burdensome and dangerous, and therefore impressive to females. The peacock is, in effect, saying: ``Look how fit and strong I must be, since I can afford to carry around this preposterous tail."

To avoid misunderstanding of the subjective language in which Zahavi likes to make his points, I should add that the biologist's convention of personifying the unconscious actions of natural selection is taken for granted here. Grafen has translated the argument into an orthodox Darwinian mathematical model, and it works. No claim is here being made about the intentionality or awareness of peacocks and peahens. They can be as sphexish or as intentional as you please (Dennett, 1983, 1984). Moreover, Zahavi's theory is general enough not to depend upon a Darwinian underpinning. A flower advertising its nectar to a ``skeptical" bee could benefit from the Zahavi principle. But so could a human salesman seeking to impress a client.

The premise of Zahavi's idea is that natural selection will favor skepticism among females (or among recipients of advertising messages generally). The only way for a male (or any advertiser) to authenticate his boast of strength (quality, or whatever is is) is to prove that it is true by shouldering a truly costly handicap --- a handicap *that only a genuinely strong* (high quality, etc.) male could bear. It may be called the principle of costly authentication. And now to the point. Is it possible that some religious doctrines are favored not *in spite of* being ridiculous but precisely *because* they are ridiculous? Any wimp in religion could believe that bread *symbolically* represents the body of Christ, but it takes a real, red-blooded Catholic to believe something as daft as the transubstantiation. If you believe that you can believe anything, and (witness the story of Doubting Thomas) these people are trained to see that as a virtue.

Let us return to our list of symptoms that someone afflicted with the mental virus of faith, and its accompanying gang of secondary infections, may expect to experience.

4. The sufferer may find himself behaving intolerantly towards vectors of rival faiths, in extreme cases even killing them or advocating their deaths. He may be similarly violent in his disposition towards apostates (people who once held the faith but have renounced it); or towards heretics (people who espouse a different --- often, perhaps significantly, only very slightly different --- version of the faith). He may also feel hostile towards other modes of thought that are potentially inimical to his faith, such as the method of scientific reason which may function rather like a piece of anti-viral software.

The threat to kill the distinguished novelist Salman Rushdie is only the latest in a long line of sad examples. On the very day that I wrote this, the Japanese translator of *The Satanic Verses* was found murdered, a week after a near-fatal attack on the Italian translator of the same book. By the way, the apparently opposite symptom of ``sympathy'' for Muslim ``hurt,'' voiced by the Archbishop of Canterbury and other Christian leaders (verging, in the case of the Vatican, on outright criminal complicity) is, of course, a manifestation of the symptom we discussed earlier: the delusion that faith, however obnoxious its results, has to be respected simply because it *is* faith.

Murder is an extreme, of course. But there is an even more extreme symptom, and that is suicide in the militant service of a faith. Like a soldier ant programmed to sacrifice her life for germ-line copies of the genes that did the programming, a young Arab or Japanese [??!] is taught that to die in a holy war is the quickest way to heaven. Whether the leaders who exploit him really believe this does not diminish the brutal power that the ``suicide mission virus'' wields on behalf of the faith. Of course suicide, like murder, is a mixed blessing: would-be converts may be repelled, or may treat with contempt a faith that is perceived as insecure enough to need such tactics.

More obviously, if too many individuals sacrifice themselves the supply of believers could run low. This was true of a notorious example of faith-inspired suicide, though in this case it was not ``kamikaze'' death in battle. The Peoples' Temple sect became extinct when its leader, the Reverend Jim Jones, led the bulk of his followers from the United States to the Promised Land of ``Jonestown'' in the Guyanan jungle where he persuaded more than 900 of them, children first, to drink cyanide. The macabre affair was fully investigated by a team from the *San Francisco Chronicle* (Kilduff and Javers, 1978).

> Jones, ``the Father,'' had called his flock together and told them it was time to depart for heaven.
> ``We're going to meet,'' he promised, ``in another place.''
> The words kept coming over the camp's loudspeakers.
> ``There is great dignity in dying. It is a great demonstration for everyone to die.''

Incidentally, it does not escape the trained mind of the alert sociobiologist that Jones, within his sect in earlier days, ``proclaimed himself the only person permitted to have sex'' (presumably his partners were also permitted). ``A secretary would arrange for Jones's liaisons. She would call up and say, `Father hates to do this, but he has this tremendous urge and could you please...?' '' His victims were not only female. One 17-year-old male follower, from the days when Jones's community was still in San Francisco, told how he was taken for dirty weekends to a hotel where Jones received a ``minister's discount for Rev. Jim Jones and son.'' The same boy said: ``I was really in awe of him. He was more than a father. I would have killed my parents for him.'' What is remarkable about the Reverend Jim Jones is not his own self-serving behavior but the almost superhuman gullibility of his

followers. Given such prodigious credulity, can anyone doubt that human minds are ripe for malignant infection?

Admittedly, the Reverend Jones conned only a few thousand people. But his case is an extreme, the tip of an iceberg. The same eagerness to be conned by religious leaders is widespread. Most of us would have been prepared to bet that nobody could get away with going on television and saying, in all but so many words, ``Send me your money, so that I can use it to persuade other suckers to send me their money too.'' Yet today, in every major conurbation in the United States, you can find at least one television evangelist channel entirely devoted to this transparent confidence trick. And they get away with it in sackfuls. Faced with suckerdom on this awesome scale, it is hard not to feel a grudging sympathy with the shiny-suited conmen. Until you realize that not all the suckers are rich, and that it is often widows' mites on which the evangelists are growing fat. I have even heard one of them explicitly invoking the principle that I now identify with Zahavi's principle of costly authentication. God really appreciates a donation, he said with passionate sincerity, only when that donation is so large that it hurts. Elderly paupers were wheeled on to testify how much happier they felt since they had made over their little all to the Reverend whoever it was.

5. The patient may notice that the particular convictions that he holds, while having nothing to do with evidence, do seem to owe a great deal to epidemiology. Why, he may wonder, do I hold *this* set of convictions rather than *that* set? Is it because I surveyed all the world's faiths and chose the one whose claims seemed most convincing? Almost certainly not. If you have a faith, it is statistically overwhelmingly likely that it is the same faith as your parents and grandparents had. No doubt soaring cathedrals, stirring music, moving stories and parables, help a bit. But by far the most important variable determining your religion is the accident of birth. The convictions that you so passionately believe would have been a completely different, and largely contradictory, set of convictions, if only you had happened to be born in a different place. Epidemiology, not evidence.

6. If the patient is one of the rare exceptions who follows a different religion from his parents, the explanation may still be epidemiological. To be sure, it is *possible* that he dispassionately surveyed the world's faiths and chose the most convincing one. But it is statistically more probable that he has been exposed to a particularly potent infective agent --- a John Wesley, a Jim Jones or a St. Paul. Here we are talking about horizontal transmission, as in measles. Before, the epidemiology was that of vertical transmission, as in Huntington's Chorea.

7. The internal sensations of the patient may be startlingly reminiscent of those more ordinarily associated with sexual love. This is an extremely potent force in the brain, and it is not surprising that some viruses have evolved to exploit it. St. Teresa of Avila's famously orgasmic vision is too notorious to need quoting again. More seriously, and on a less crudely sensual plane, the philosophy Anthony Kenny provides moving testimony to the pure delight that awaits those that manage to believe in the mystery of transubstantiation. After describing his ordination as a Roman Catholic priest, empowered by laying on of hands to celebrate Mass, he goes on that he vividly recalls

> the exaltation of the first months during which I had the power to say Mass. Normally a slow and sluggish riser, I would leap early out of bed, fully awake and full of excitement at the thought of the momentous act I was privileged to perform. I rarely said the public Community Mass: most days I celebrated alone at a side altar with a junior member of the College to serve as acolyte and congregation. But that made no difference to the solemnity of the sacrifice or the validity of the consecration.
>
> It was touching the body of Christ, the closeness of the priest to Jesus, which most enthralled me. I would gaze on the Host after the words of consecration, soft-eyed like a lover looking

> into the eyes of his beloved... Those early days as a priest remain in my memory as days of fulfilment and tremulous happiness; something precious, and yet too fragile to last, like a romantic love-affair brought up short by the reality of an ill-assorted marriage. (Kenny, 1986, pp. 101-2)

Dr. Kenny is affectingly believable that it felt to him, as a young priest, as though he was in love with the consecrated host. What a brilliantly successful virus! On the same page, incidentally, Kenny also shows us that the virus is transmitted contagiously --- if not literally then at least in some sense --- from the palm of the infecting bishop's hand through the top of the new priest's head:

> If Catholic doctrine is true, every priest validly ordained derives his orders in an unbroken line of laying on of hands, through the bishop who ordains him, back to one of the twelve Apostles... there must be centuries-long, recorded chains of layings on of hands. It surprises me that priests never seem to trouble to trace their spiritual ancestry in this way, finding out who ordained their bishop, and who ordained him, and so on to Julius II or Celestine V or Hildebrand, or Gregory the Great, perhaps. (Kenny, 1986, p. 101)

It surprises me, too.

4 Is Science a Virus

No. Not unless all computer programs are viruses. Good, useful programs spread because people evaluate them, recommend them and pass them on. Computer viruses spread solely because they embody the coded instructions: ``Spread me.'' Scientific ideas, like all memes, are subject to a kind of natural selection, and this might look superficially virus-like. But the selective forces that scrutinize scientific ideas are not arbitrary and capricious. They are exacting, well-honed rules, and they do not favor pointless self-serving behavior. They favor all the virtues laid out in textbooks of standard methodology: testability, evidential support, precision, quantifiability, consistency, intersubjectivity, repeatability, universality, progressiveness, independence of cultural milieu, and so on. Faith spreads despite a total lack of every single one of these virtues.

You may find elements of epidemiology in the spread of scientific ideas, but it will be largely descriptive epidemiology. The rapid spread of a good idea through the scientific community may even look like a description of a measles epidemic. But when you examine the underlying reasons you find that they are good ones, satisfying the demanding standards of scientific method. In the history of the spread of faith you will find little else but epidemiology, and causal epidemiology at that. The reason why person A believes one thing and B believes another is simply and solely that A was born on one continent and B on another. Testability, evidential support and the rest aren't even remotely considered. For scientific belief, epidemiology merely comes along afterwards and describes the history of its acceptance. For religious belief, epidemiology is the root cause.

5 Epilogue

Happily, viruses don't win every time. Many children emerge unscathed from the worst that nuns and mullahs can throw at them. Anthony Kenny's own story has a happy ending. He eventually renounced his orders because he could no longer tolerate the obvious contradictions within Catholic belief, and he is now a highly respected scholar. But one cannot help remarking that it must be a powerful infection indeed that took a man of his wisdom and intelligence --- President of the British Academy, no less --- three decades to fight off. Am I unduly alarmist to fear for the soul of my six-year-old innocent?

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Viruses of the Mind
Richard Dawkins

1991

> The haven all memes depend on reaching is the human mind, but a human mind is itself an artifact created when memes restructure a human brain in order to make it a better habitat for memes. The avenues for entry and departure are modified to suit local conditions, and strengthened by various artificial devices that enhance fidelity and prolixity of replication: native Chinese minds differ dramatically from native French minds, and literate minds differ from illiterate minds. What memes provide in return to the organisms in which they reside is an incalculable store of advantages --- with some Trojan horses thrown in for good measure. . .
>
> Daniel Dennett, *Consciousness Explained*

1 Duplication Fodder

A beautiful child close to me, six and the apple of her father's eye, believes that Thomas the Tank Engine really exists. She believes in Father Christmas, and when she grows up her ambition is to be a tooth fairy. She and her school-friends believe the solemn word of respected adults that tooth fairies and Father Christmas really exist. This little girl is of an age to believe whatever you tell her. If you tell her about witches changing princes into frogs she will believe you. If you tell her that bad children roast forever in hell she will have nightmares. I have just discovered that without her father's consent this sweet, trusting, gullible six-year-old is being sent, for weekly instruction, to a Roman Catholic nun. What chance has she?

A human child is shaped by evolution to soak up the culture of her people. Most obviously, she learns the essentials of their language in a matter of months. A large dictionary of words to speak, an encyclopedia of information to speak about, complicated syntactic and semantic rules to order the speaking, are all transferred from older brains into hers well before she reaches half her adult size. When you are pre-programmed to absorb useful information at a high rate, it is hard to shut out pernicious or damaging information at the same time. With so many mindbytes to be downloaded, so many mental codons to be replicated, it is no wonder that child brains are gullible, open to almost any suggestion, vulnerable to subversion, easy prey to Moonies, Scientologists and nuns. Like immune-deficient patients, children are wide open to mental infections that adults might brush off without effort.

DNA, too, includes parasitic code. Cellular machinery is extremely good at copying DNA. Where DNA is concerned, it seems to have an eagerness to copy, seems eager to be copied. The cell nucleus is a paradise for DNA, humming with sophisticated, fast, and accurate duplicating machinery.

Cellular machinery is so friendly towards DNA duplication that it is small wonder cells play host to DNA parasites --- viruses, viroids, plasmids and a riff-raff of other genetic fellow travelers. Parasitic DNA even gets itself spliced seamlessly into the chromosomes themselves. ``Jumping genes'' and stretches of ``selfish DNA'' cut or copy themselves out of chromosomes and paste themselves in elsewhere. Deadly oncogenes are almost impossible to distinguish from the legitimate genes

between which they are spliced. In evolutionary time, there is probably a continual traffic from ``straight'' genes to ``outlaw,'' and back again (Dawkins, 1982). DNA is just DNA. The only thing that distinguishes viral DNA from host DNA is its expected method of passing into future generations. ``Legitimate'' host DNA is just DNA that aspires to pass into the next generation via the orthodox route of sperm or egg. ``Outlaw'' or parasitic DNA is just DNA that looks to a quicker, less cooperative route to the future, via a squeezed droplet or a smear of blood, rather than via a sperm or egg.

For data on a floppy disc, a computer is a humming paradise just as cell nuclei hum with eagerness to duplicate DNA. Computers and their associated disc and tape readers are designed with high fidelity in mind. As with DNA molecules, magnetized bytes don't literally ``want'' to be faithfully copied. Nevertheless, you can write a computer program that takes steps to duplicate itself. Not just duplicate itself within one computer but spread itself to other computers. Computers are so good at copying bytes, and so good at faithfully obeying the instructions contained in those bytes, that they are sitting ducks to self-replicating programs: wide open to subversion by software parasites. Any cynic familiar with the theory of selfish genes and memes would have known that modern personal computers, with their promiscuous traffic of floppy discs and e-mail links, were just asking for trouble. The only surprising thing about the current epidemic of computer viruses is that it has been so long in coming.

2 Computer Viruses: a Model for an Informational Epidemiology

Computer viruses are pieces of code that graft themselves into existing, legitimate programs and subvert the normal actions of those programs. They may travel on exchanged floppy disks, or over networks. They are technically distinguished from ``worms'' which are whole programs in their own right, usually traveling over networks. Rather different are ``Trojan horses,'' a third category of destructive programs, which are not in themselves self-replicating but rely on humans to replicate them because of their pornographic or otherwise appealing content. Both viruses and worms are programs that actually say, in computer language, ``Duplicate me.'' Both may do other things that make their presence felt and perhaps satisfy the hole-in-corner vanity of their authors. These side-effects may be ``humorous'' (like the virus that makes the Macintosh's built-in loudspeaker enunciate the words ``Don't panic,'' with predictably opposite effect); malicious (like the numerous IBM viruses that erase the hard disk after a sniggering screen-announcement of the impending disaster); political (like the Spanish Telecom and Beijing viruses that protest about telephone costs and massacred students respectively); or simply inadvertent (the programmer is incompetent to handle the low-level system calls required to write an effective virus or worm). The famous Internet Worm, which paralyzed much of the computing power of the United States on November 2, 1988, was not intended (very) maliciously but got out of control and, within 24 hours, had clogged around 6,000 computer memories with exponentially multiplying copies of itself.

``Memes now spread around the world at the speed of light, and replicate at rates that make even fruit flies and yeast cells look glacial in comparison. They leap promiscuously from vehicle to vehicle, and from medium to medium, and are proving to be virtually unquarantinable'' (Dennett 1990, p.131). Viruses aren't limited to electronic media such as disks and data lines. On its way from one computer to another, a virus may pass through printing ink, light rays in a human lens, optic nerve impulses and finger muscle contractions. A computer fanciers' magazine that printed the text of a virus program for the interest of its readers has been widely condemned. Indeed, such is the appeal of the virus idea to a certain kind of puerile mentality (the masculine gender is used

advisedly), that publication of any kind of ``how to'' information on designing virus programs is rightly seen as an irresponsible act.

I am not going to publish any virus code. But there are certain tricks of effective virus design that are sufficiently well known, even obvious, that it will do no harm to mention them, as I need to do to develop my theme. They all stem from the virus's need to evade detection while it is spreading.

A virus that clones itself too prolifically within one computer will soon be detected because the symptoms of clogging will become too obvious to ignore. For this reason many virus programs check, before infecting a system, to make sure that they are not already on that system. Incidentally, this opens the way for a defense against viruses that is analogous to immunization. In the days before a specific anti-virus program was available, I myself responded to an early infection of my own hard disk by means of a crude ``vaccination.'' Instead of deleting the virus that I had detected, I simply disabled its coded instructions, leaving the ``shell'' of the virus with its characteristic external ``signature'' intact. In theory, subsequent members of the same virus species that arrived in my system should have recognized the signature of their own kind and refrained from trying to double-infect. I don't know whether this immunization really worked, but in those days it probably was worth while ``gutting'' a virus and leaving a shell like this, rather than simply removing it lock, stock and barrel. Nowadays it is better to hand the problem over to one of the professionally written anti-virus programs.

A virus that is too virulent will be rapidly detected and scotched. A virus that instantly and catastrophically sabotages every computer in which it finds itself will not find itself in many computers. It may have a most amusing effect on one computer ---- erase an entire doctoral thesis or something equally side-splitting --- but it won't spread as an epidemic.

Some viruses, therefore, are designed to have an effect that is small enough to be difficult to detect, but which may nevertheless be extremely damaging. There is one type, which, instead of erasing disk sectors wholesale, attacks only spreadsheets, making a few random changes in the (usually financial) quantities entered in the rows and columns. Other viruses evade detection by being triggered probabilistically, for example erasing only one in 16 of the hard disks infected. Yet other viruses employ the time-bomb principle. Most modern computers are ``aware'' of the date, and viruses have been triggered to manifest themselves all around the world, on a particular date such as Friday 13th or April Fool's Day. From the parasitic point of view, it doesn't matter how catastrophic the eventual attack is, provided the virus has had plenty of opportunity to spread first (a disturbing analogy to the Medawar/Williams theory of ageing: we are the victims of lethal and sub-lethal genes that mature only after we have had plenty of time to reproduce (Williams, 1957)). In defense, some large companies go so far as to set aside one ``miner's canary'' among their fleet of computers, and advance its internal calendar a week so that any time-bomb viruses will reveal themselves prematurely before the big day.

Again predictably, the epidemic of computer viruses has triggered an arms race. Anti-viral software is doing a roaring trade. These antidote programs -- ``Interferon,'' ``Vaccine,'' ``Gatekeeper'' and others --- employ a diverse armory of tricks. Some are written with specific, known and named viruses in mind. Others intercept any attempt to meddle with sensitive system areas of memory and warn the user.

The virus principle could, in theory, be used for non-malicious, even beneficial purposes. Thimbleby (1991) coins the phrase ``liveware'' for his already-implemented use of the infection principle for keeping multiple copies of databases up to date. Every time a disk containing the database is

plugged into a computer, it looks to see whether there is already another copy present on the local hard disk. If there is, each copy is updated in the light of the other. So, with a bit of luck, it doesn't matter which member of a circle of colleagues enters, say, a new bibliographical citation on his personal disk. His newly entered information will readily infect the disks of his colleagues (because the colleagues promiscuously insert their disks into one another's computers) and will spread like an epidemic around the circle. Thimbleby's liveware is not entirely virus-like: it could not spread to just anybody's computer and do damage. It spreads data only to already-existing copies of its own database; and you will not be infected by liveware unless you positively opt for infection.

Incidentally, Thimbleby, who is much concerned with the virus menace, points out that you can gain some protection by using computer systems that other people don't use. The usual justification for purchasing today's numerically dominant computer is simply and solely that it *is* numerically dominant. Almost every knowledgeable person agrees that, in terms of quality and especially user-friendliness, the rival, minority system is superior. Nevertheless, ubiquity is held to be good in itself, sufficient to outweigh sheer quality. Buy the same (albeit inferior) computer as your colleagues, the argument goes, and you'll be able to benefit from shared software, and from a generally large circulation of available software. The irony is that, with the advent of the virus plague, ``benefit'' is not all that you are likely to get. Not only should we all be very hesitant before we accept a disk from a colleague. We should also be aware that, if we join a large community of users of a particular make of computer, we are also joining a large community of viruses --- even, it turns out, *disproportionately* larger.

Returning to possible uses of viruses for positive purposes, there are proposals to exploit the ``poacher turned gamekeeper'' principle, and ``set a thief to catch a thief.'' A simple way would be to take any of the existing anti-viral programs and load it, as a ``warhead,'' into a harmless self-replicating virus. From a ``public health'' point of view, a spreading epidemic of anti-viral software could be especially beneficial because the computers most vulnerable to malicious viruses --- those whose owners are promiscuous in the exchange of pirated programs --- will also be most vulnerable to infection by the healing anti-virus. A more penetrating anti-virus might --- as in the immune system --- ``learn'' or ``evolve'' an improved capacity to attack whatever viruses it encountered.

I can imagine other uses of the computer virus principle which, if not exactly altruistic, are at least constructive enough to escape the charge of pure vandalism. A computer company might wish to do market research on the habits of its customers, with a view to improving the design of future products. Do users like to choose files by pictorial icon, or do they opt to display them by textual name only? How deeply do people nest folders (directories) within one another? Do people settle down for a long session with only one program, say a word processors, or are they constantly switching back and forth, say between writing and drawing programs? Do people succeed in moving the mouse pointer straight to the target, or do they meander around in time-wasting hunting movements that could be rectified by a change in design?

The company could send out a questionnaire asking all these questions, but the customers that replied would be a biased sample and, in any case, their own assessment of their computer-using behavior might be inaccurate. A better solution would be a market-research computer program. Customers would be asked to load this program into their system where it would unobtrusively sit, quietly monitoring and tallying key-presses and mouse movements. At the end of a year, the customer would be asked to send in the disk file containing all the tallyings of the market-research program. But again, most people would not bother to cooperate and some might see it as an invasion of privacy and of their disk space.

The perfect solution, from the company's point of view, would be a virus. Like any other virus, it would be self-replicating and secretive. But it would not be destructive or facetious like an ordinary virus. Along with its self-replicating booster it would contain a market-research warhead. The virus would be released surreptitiously into the community of computer users. Just like an ordinary virus it would spread around, as people passed floppy disks and e-mail around the community. As the virus spread from computer to computer, it would build up statistics on users behavior, monitored secretly from deep within a succession of systems. Every now and again, a copy of the viruses would happen to find its way, by normal epidemic traffic, back into one of the company's own computers. There it would be debriefed and its data collated with data from other copies of the virus that had come ``home."

Looking into the future, it is not fanciful to imagine a time when viruses, both bad and good, have become so ubiquitous that we could speak of an ecological community of viruses and legitimate programs coexisting in the silicosphere. At present, software is advertised as, say, ``Compatible with System 7." In the future, products may be advertised as ``Compatible with all viruses registered in the 1998 World Virus Census; immune to all listed virulent viruses; takes full advantage of the facilities offered by the following benign viruses if present..." Word-processing software, say, may hand over particular functions, such as word-counting and string-searches, to friendly viruses burrowing autonomously through the text.

Looking even further into the future, whole integrated software systems might grow, not by design, but by something like the growth of an ecological community such as a tropical rain-forest. Gangs of mutually compatible viruses might grow up, in the same way as genomes can be regarded as gangs of mutually compatible genes (Dawkins, 1982). Indeed, I have even suggested that our genomes should be regarded as gigantic colonies of viruses (Dawkins, 1976). Genes cooperate with one another in genomes because natural selection has favored those genes that prosper in the presence of the other genes that happen to be common in the gene pool. Different gene pools may evolve towards different combinations of mutually compatible genes. I envisage a time when, in the same kind of way, computer viruses may evolve towards compatibility with other viruses, to form communities or gangs. But then again, perhaps not! At any rate, I find the speculation more alarming than exciting.

At present, computer viruses don't strictly evolve. They are invented by human programmers, and if they evolve they do so in the same weak sense as cars or aeroplanes evolve. Designers derive this year's car as a slight modification of last year's car, and then may, more or less consciously, continue a trend of the last few years --- further flattening of the radiator grill or whatever it may be. Computer virus designers dream up ever more devious tricks for outwitting the programmers of anti-virus software. But computer viruses don't --- so far --- mutate and evolve by true natural selection. They may do so in the future. Whether they evolve by natural selection, or whether their evolution is steered by human designers, may not make much difference to their eventual performance. By either kind of evolution, we expect them to become better at concealment, and we expect them to become subtly compatible with other viruses that are at the same time prospering in the computer community.

DNA viruses and computer viruses spread for the same reason: an environment exists in which there is machinery well set up to duplicate and spread them around and to obey the instructions that the viruses embody. These two environments are, respectively, the environment of cellular physiology and the environment provided by a large community of computers and data-handling machinery. Are there any other environments like these, any other humming paradises of replication?

3 The Infected Mind

I have already alluded to the programmed-in gullibility of a child, so useful for learning language and traditional wisdom, and so easily subverted by nuns, Moonies and their ilk. More generally, we all exchange information with one another. We don't exactly plug floppy disks into slots in one another's skulls, but we exchange sentences, both through our ears and through our eyes. We notice each other's styles of moving and dressing and are influenced. We take in advertising jingles, and are presumably persuaded by them, otherwise hard-headed businessmen would not spend so much money polluting their air with them.

Think about the two qualities that a virus, or any sort of parasitic replicator, demands of a friendly medium,. the two qualities that make cellular machinery so friendly towards parasitic DNA, and that make computers so friendly towards computer viruses. These qualities are, firstly, a readiness to replicate information accurately, perhaps with some mistakes that are subsequently reproduced accurately; and, secondly, a readiness to obey instructions encoded in the information so replicated.

Cellular machinery and electronic computers excel in both these virus-friendly qualities. How do human brains match up? As faithful duplicators, they are certainly less perfect than either cells or electronic computers. Nevertheless, they are still pretty good, perhaps about as faithful as an RNA virus, though not as good as DNA with all its elaborate proofreading measures against textual degradation. Evidence of the fidelity of brains, especially child brains, as data duplicators is provided by language itself. Shaw's Professor Higgins was able by ear alone to place Londoners in the street where they grew up. Fiction is not evidence for anything, but everyone knows that Higgins's fictional skill is only an exaggeration of something we can all down. Any American can tell Deep South from Mid West, New England from Hillbilly. Any New Yorker can tell Bronx from Brooklyn. Equivalent claims could be substantiated for any country. What this phenomenon means is that human brains are capable of pretty accurate copying (otherwise the accents of, say, Newcastle would not be stable enough to be recognized) but with some mistakes (otherwise pronunciation would not evolve, and all speakers of a language would inherit identically the same accents from their remote ancestors). Language evolves, because it has both the great stability and the slight changeability that are prerequisites for any evolving system.

The second requirement of a virus-friendly environment --- that it should obey a program of coded instructions --- is again only quantitatively less true for brains than for cells or computers. We sometimes obey orders from one another, but also we sometimes don't. Nevertheless, it is a telling fact that, the world over, the vast majority of children follow the religion of their parents rather than any of the other available religions. Instructions to genuflect, to bow towards Mecca, to nod one's head rhythmically towards the wall, to shake like a maniac, to ``speak in tongues'' --- the list of such arbitrary and pointless motor patterns offered by religion alone is extensive --- are obeyed, if not slavishly, at least with some reasonably high statistical probability.

Less portentously, and again especially prominent in children, the ``craze'' is a striking example of behavior that owes more to epidemiology than to rational choice. Yo-yos, hula hoops and pogo sticks, with their associated behavioral fixed actions, sweep through schools, and more sporadically leap from school to school, in patterns that differ from a measles epidemic in no serious particular. Ten years ago, you could have traveled thousands of miles through the United States and never seen a baseball cap turned back to front. Today, the reverse baseball cap is ubiquitous. I do not know what the pattern of geographical spread of the reverse baseball cap precisely was, but epidemiology is certainly among the professions primarily qualified to study it. We don't have to get into arguments about ``determinism''; we don't have to claim that children are compelled to imitate their

fellows' hat fashions. It is enough that their hat-wearing behavior, as a matter of fact, *is* statistically affected by the hat-wearing behavior of their fellows.

Trivial though they are, crazes provide us with yet more circumstantial evidence that human minds, especially perhaps juvenile ones, have the qualities that we have singled out as desirable for an informational parasite. At the very least the mind is a plausible *candidate* for infection by something like a computer virus, even if it is not quite such a parasite's dream-environment as a cell nucleus or an electronic computer.

It is intriguing to wonder what it might feel like, from the inside, if one's mind were the victim of a ``virus." This might be a deliberately designed parasite, like a present-day computer virus. Or it might be an inadvertently mutated and unconsciously evolved parasite. Either way, especially if the evolved parasite was the memic descendant of a long line of successful ancestors, we are entitled to expect the typical ``mind virus" to be pretty good at its job of getting itself successfully replicated.

Progressive evolution of more effective mind-parasites will have two aspects. New ``mutants" (either random or designed by humans) that are better at spreading will become more numerous. And there will be a ganging up of ideas that flourish in one another's presence, ideas that mutually support one another just as genes do and as I have speculated computer viruses may one day do. We expect that replicators will go around together from brain to brain in mutually compatible gangs. These gangs will come to constitute a package, which may be sufficiently stable to deserve a collective name such as Roman Catholicism or Voodoo. It doesn't too much matter whether we analogize the whole package to a single virus, to each one of the component parts to a single virus. The analogy is not that precise anyway, just as the distinction between a computer virus and a computer worm is nothing to get worked up about. What matters is that minds are friendly environments to parasitic, self-replicating ideas or information, and that minds are typically massively infected.

Like computer viruses, successful mind viruses will tend to be hard for their victims to detect. If you are the victim of one, the chances are that you won't know it, and may even vigorously deny it. Accepting that a virus might be difficult to detect in your own mind, what tell-tale signs might you look out for? I shall answer by imaging how a medical textbook might describe the typical symptoms of a sufferer (arbitrarily assumed to be male).

1. The patient typically finds himself impelled by some deep, inner conviction that something is true, or right, or virtuous: a conviction that doesn't seem to owe anything to evidence or reason, but which, nevertheless, he feels as totally compelling and convincing. We doctors refer to such a belief as ``faith."

2. Patients typically make a positive virtue of faith's being strong and unshakable, *in spite of* not being based upon evidence. Indeed, they may fell that the less evidence there is, the more virtuous the belief (see below).

This paradoxical idea that lack of evidence is a positive virtue where faith is concerned has something of the quality of a program that is self-sustaining, because it is self-referential (see the chapter ``On Viral Sentences and Self-Replicating Structures" in Hofstadter, 1985). Once the proposition is believed, it automatically undermines opposition to itself. The ``lack of evidence is a virtue" idea could be an admirable sidekick, ganging up with faith itself in a clique of mutually supportive viral programs.

3. A related symptom, which a faith-sufferer may also present, is the conviction that ``mystery," *per*

se, is a good thing. It is not a virtue to solve mysteries. Rather we should enjoy them, even revel in their insolubility.

Any impulse to solve mysteries could be serious inimical to the spread of a mind virus. It would not, therefore, be surprising if the idea that ``mysteries are better not solved'' was a favored member of a mutually supporting gang of viruses. Take the ``Mystery of Transubstantiation.'' It is easy and non-mysterious to believe that in some symbolic or metaphorical sense the eucharistic wine turns into the blood of Christ. The Roman Catholic doctrine of transubstantiation, however, claims far more. The ``whole substance'' of the wine is converted into the blood of Christ; the appearance of wine that remains is ``merely accidental,'' ``inhering in no substance'' (Kenny, 1986, p. 72). Transubstantiation is colloquially taught as meaning that the wine ``literally'' turns into the blood of Christ. Whether in its obfuscatory Aristotelian or its franker colloquial form, the claim of transubstantiation can be made only if we do serious violence to the normal meanings of words like ``substance'' and ``literally.'' Redefining words is not a sin, but, if we use words like ``whole substance'' and ``literally'' for this case, what word are we going to use when we really and truly *want* to say that something did actually happen? As Anthony Kenny observed of his own puzzlement as a young seminarian, ``For all I could tell, my typewriter might be Benjamin Disraeli transubstantiated....''

Roman Catholics, whose belief in infallible authority compels them to accept that wine becomes physically transformed into blood despite all appearances, refer to the ``mystery'' of transubstantiation. Calling it a mystery makes everything OK, you see. At least, it works for a mind well prepared by background infection. Exactly the same trick is performed in the ``mystery'' of the Trinity. Mysteries are not meant to be solved, they are meant to strike awe. The ``mystery is a virtue'' idea comes to the aid of the Catholic, who would otherwise find intolerable the obligation to believe the obvious nonsense of the transubstantiation and the ``three-in-one.'' Again, the belief that ``mystery is a virtue'' has a self-referential ring. As Hofstadter might put it, the very mysteriousness of the belief moves the believer to perpetuate the mystery.

An extreme symptom of ``mystery is a virtue'' infection is Tertullian's ``*Certum est quia impossibile est*'' (It is certain because it is impossible''). That way madness lies. One is tempted to quote Lewis Carroll's White Queen, who, in response to Alice's ``One can't believe impossible things'' retorted ``I daresay you haven't had much practice... When I was your age, I always did it for half-an-hour a day. Why, sometimes I've believed as many as six impossible things before breakfast.'' Or Douglas Adam's Electric Monk, a labor-saving device programmed to do your believing for you, which was capable of ``believing things they'd have difficulty believing in Salt Lake City'' and which, at the moment of being introduced to the reader, believed, contrary to all the evidence, that everything in the world was a uniform shade of pink. But White Queens and Electric Monks become less funny when you realize that these virtuoso believers are indistinguishable from revered theologians in real life. ``It is by all means to be believed, because it is absurd'' (Tertullian again). Sir Thomas Browne (1635) quotes Tertullian with approval, and goes further: ``Methinks there be not impossibilities enough in religion for an active faith.'' And ``I desire to exercise my faith in the difficultest point; for to credit ordinary and visible objects is not faith, but perswasion [sic].''

I have the feeling that something more interesting is going on here than just plain insanity or surrealist nonsense, something akin to the admiration we feel when we watch a ten-ball juggler on a tightrope. It is as though the faithful gain prestige through managing to believe even more impossible things than their rivals succeed in believing. Are these people testing --- exercising --- their believing muscles, training themselves to believe impossible things so that they can take in their stride the merely improbable things that they are ordinarily called upon to believe?

While I was writing this, the *Guardian* (July 29, 1991) fortuitously carried a beautiful example. It came in an interview with a rabbi undertaking the bizarre task of vetting the kosher-purity of food products right back to the ultimate origins of their minutest ingredients. He was currently agonizing over whether to go all the way to China to scrutinize the menthol that goes into cough sweets. ``Have you ever tried checking Chinese menthol... it was extremely difficult, especially since the first letter we sent received the reply in best Chinese English, `The product contains no kosher'... China has only recently started opening up to kosher investigators. The menthol should be OK, but you can never be absolutely sure unless you visit." These kosher investigators run a telephone hot-line on which up-to-the-minute red-alerts of suspicion are recorded against chocolate bars and cod-liver oil. The rabbi sighs that the green-inspired trend away from artificial colors and flavors ``makes life miserable in the kosher field because you have to follow all these things back." When the interviewer asks him why he bothers with this obviously pointless exercise, he makes it very clear that the point is precisely that there *is* no point:

> That most of the Kashrut laws are divine ordinances without reason given is 100 per cent the point. It is very easy not to murder people. Very easy. It is a little bit harder not to steal because one is tempted occasionally. So that is no great proof that I believe in God or am fulfilling His will. But, if He tells me not to have a cup of coffee with milk in it with my mincemeat and peaces at lunchtime, that is a test. The only reason I am doing that is because I have been told to so do. It is something difficult.

Helena Cronin has suggested to me that there may be an analogy here to Zahavi's handicap theory of sexual selection and the evolution of signals (Zahavi, 1975). Long unfashionable, even ridiculed (Dawkins, 1976), Zahavi's theory has recently been cleverly rehabilitated (Grafen, 1990 a, b) and is now taken seriously by evolutionary biologists (Dawkins, 1989). Zahavi suggests that peacocks, for instance, evolve their absurdly burdensome fans with their ridiculously conspicuous (to predators) colors, precisely *because* they are burdensome and dangerous, and therefore impressive to females. The peacock is, in effect, saying: ``Look how fit and strong I must be, since I can afford to carry around this preposterous tail."

To avoid misunderstanding of the subjective language in which Zahavi likes to make his points, I should add that the biologist's convention of personifying the unconscious actions of natural selection is taken for granted here. Grafen has translated the argument into an orthodox Darwinian mathematical model, and it works. No claim is here being made about the intentionality or awareness of peacocks and peahens. They can be as sphexish or as intentional as you please (Dennett, 1983, 1984). Moreover, Zahavi's theory is general enough not to depend upon a Darwinian underpinning. A flower advertising its nectar to a ``skeptical" bee could benefit from the Zahavi principle. But so could a human salesman seeking to impress a client.

The premise of Zahavi's idea is that natural selection will favor skepticism among females (or among recipients of advertising messages generally). The only way for a male (or any advertiser) to authenticate his boast of strength (quality, or whatever is is) is to prove that it is true by shouldering a truly costly handicap --- a handicap *that only a genuinely strong* (high quality, etc.) male could bear. It may be called the principle of costly authentication. And now to the point. Is it possible that some religious doctrines are favored not *in spite of* being ridiculous but precisely *because* they are ridiculous? Any wimp in religion could believe that bread *symbolically* represents the body of Christ, but it takes a real, red-blooded Catholic to believe something as daft as the transubstantiation. If you believe that you can believe anything, and (witness the story of Doubting Thomas) these people are trained to see that as a virtue.

Let us return to our list of symptoms that someone afflicted with the mental virus of faith, and its accompanying gang of secondary infections, may expect to experience.

4. The sufferer may find himself behaving intolerantly towards vectors of rival faiths, in extreme cases even killing them or advocating their deaths. He may be similarly violent in his disposition towards apostates (people who once held the faith but have renounced it); or towards heretics (people who espouse a different --- often, perhaps significantly, only very slightly different --- version of the faith). He may also feel hostile towards other modes of thought that are potentially inimical to his faith, such as the method of scientific reason which may function rather like a piece of anti-viral software.

The threat to kill the distinguished novelist Salman Rushdie is only the latest in a long line of sad examples. On the very day that I wrote this, the Japanese translator of *The Satanic Verses* was found murdered, a week after a near-fatal attack on the Italian translator of the same book. By the way, the apparently opposite symptom of ``sympathy'' for Muslim ``hurt,'' voiced by the Archbishop of Canterbury and other Christian leaders (verging, in the case of the Vatican, on outright criminal complicity) is, of course, a manifestation of the symptom we discussed earlier: the delusion that faith, however obnoxious its results, has to be respected simply because it *is* faith.

Murder is an extreme, of course. But there is an even more extreme symptom, and that is suicide in the militant service of a faith. Like a soldier ant programmed to sacrifice her life for germ-line copies of the genes that did the programming, a young Arab or Japanese [??!] is taught that to die in a holy war is the quickest way to heaven. Whether the leaders who exploit him really believe this does not diminish the brutal power that the ``suicide mission virus'' wields on behalf of the faith. Of course suicide, like murder, is a mixed blessing: would-be converts may be repelled, or may treat with contempt a faith that is perceived as insecure enough to need such tactics.

More obviously, if too many individuals sacrifice themselves the supply of believers could run low. This was true of a notorious example of faith-inspired suicide, though in this case it was not ``kamikaze'' death in battle. The Peoples' Temple sect became extinct when its leader, the Reverend Jim Jones, led the bulk of his followers from the United States to the Promised Land of ``Jonestown'' in the Guyanan jungle where he persuaded more than 900 of them, children first, to drink cyanide. The macabre affair was fully investigated by a team from the *San Francisco Chronicle* (Kilduff and Javers, 1978).

> Jones, ``the Father,'' had called his flock together and told them it was time to depart for heaven.
> ``We're going to meet,'' he promised, ``in another place.''
> The words kept coming over the camp's loudspeakers.
> ``There is great dignity in dying. It is a great demonstration for everyone to die.''

Incidentally, it does not escape the trained mind of the alert sociobiologist that Jones, within his sect in earlier days, ``proclaimed himself the only person permitted to have sex'' (presumably his partners were also permitted). ``A secretary would arrange for Jones's liaisons. She would call up and say, `Father hates to do this, but he has this tremendous urge and could you please...?' '' His victims were not only female. One 17-year-old male follower, from the days when Jones's community was still in San Francisco, told how he was taken for dirty weekends to a hotel where Jones received a ``minister's discount for Rev. Jim Jones and son.'' The same boy said: ``I was really in awe of him. He was more than a father. I would have killed my parents for him.'' What is remarkable about the Reverend Jim Jones is not his own self-serving behavior but the almost superhuman gullibility of his

followers. Given such prodigious credulity, can anyone doubt that human minds are ripe for malignant infection?

Admittedly, the Reverend Jones conned only a few thousand people. But his case is an extreme, the tip of an iceberg. The same eagerness to be conned by religious leaders is widespread. Most of us would have been prepared to bet that nobody could get away with going on television and saying, in all but so many words, ``Send me your money, so that I can use it to persuade other suckers to send me their money too." Yet today, in every major conurbation in the United States, you can find at least one television evangelist channel entirely devoted to this transparent confidence trick. And they get away with it in sackfuls. Faced with suckerdom on this awesome scale, it is hard not to feel a grudging sympathy with the shiny-suited conmen. Until you realize that not all the suckers are rich, and that it is often widows' mites on which the evangelists are growing fat. I have even heard one of them explicitly invoking the principle that I now identify with Zahavi's principle of costly authentication. God really appreciates a donation, he said with passionate sincerity, only when that donation is so large that it hurts. Elderly paupers were wheeled on to testify how much happier they felt since they had made over their little all to the Reverend whoever it was.

5. The patient may notice that the particular convictions that he holds, while having nothing to do with evidence, do seem to owe a great deal to epidemiology. Why, he may wonder, do I hold *this* set of convictions rather than *that* set? Is it because I surveyed all the world's faiths and chose the one whose claims seemed most convincing? Almost certainly not. If you have a faith, it is statistically overwhelmingly likely that it is the same faith as your parents and grandparents had. No doubt soaring cathedrals, stirring music, moving stories and parables, help a bit. But by far the most important variable determining your religion is the accident of birth. The convictions that you so passionately believe would have been a completely different, and largely contradictory, set of convictions, if only you had happened to be born in a different place. Epidemiology, not evidence.

6. If the patient is one of the rare exceptions who follows a different religion from his parents, the explanation may still be epidemiological. To be sure, it is *possible* that he dispassionately surveyed the world's faiths and chose the most convincing one. But it is statistically more probable that he has been exposed to a particularly potent infective agent --- a John Wesley, a Jim Jones or a St. Paul. Here we are talking about horizontal transmission, as in measles. Before, the epidemiology was that of vertical transmission, as in Huntington's Chorea.

7. The internal sensations of the patient may be startlingly reminiscent of those more ordinarily associated with sexual love. This is an extremely potent force in the brain, and it is not surprising that some viruses have evolved to exploit it. St. Teresa of Avila's famously orgasmic vision is too notorious to need quoting again. More seriously, and on a less crudely sensual plane, the philosophy Anthony Kenny provides moving testimony to the pure delight that awaits those that manage to believe in the mystery of transubstantiation. After describing his ordination as a Roman Catholic priest, empowered by laying on of hands to celebrate Mass, he goes on that he vividly recalls

> the exaltation of the first months during which I had the power to say Mass. Normally a slow and sluggish riser, I would leap early out of bed, fully awake and full of excitement at the thought of the momentous act I was privileged to perform. I rarely said the public Community Mass: most days I celebrated alone at a side altar with a junior member of the College to serve as acolyte and congregation. But that made no difference to the solemnity of the sacrifice or the validity of the consecration.
>
> It was touching the body of Christ, the closeness of the priest to Jesus, which most enthralled me. I would gaze on the Host after the words of consecration, soft-eyed like a lover looking

> into the eyes of his beloved... Those early days as a priest remain in my memory as days of fulfilment and tremulous happiness; something precious, and yet too fragile to last, like a romantic love-affair brought up short by the reality of an ill-assorted marriage. (Kenny, 1986, pp. 101-2)

Dr. Kenny is affectingly believable that it felt to him, as a young priest, as though he was in love with the consecrated host. What a brilliantly successful virus! On the same page, incidentally, Kenny also shows us that the virus is transmitted contagiously --- if not literally then at least in some sense --- from the palm of the infecting bishop's hand through the top of the new priest's head:

> If Catholic doctrine is true, every priest validly ordained derives his orders in an unbroken line of laying on of hands, through the bishop who ordains him, back to one of the twelve Apostles... there must be centuries-long, recorded chains of layings on of hands. It surprises me that priests never seem to trouble to trace their spiritual ancestry in this way, finding out who ordained their bishop, and who ordained him, and so on to Julius II or Celestine V or Hildebrand, or Gregory the Great, perhaps. (Kenny, 1986, p. 101)

It surprises me, too.

4 Is Science a Virus

No. Not unless all computer programs are viruses. Good, useful programs spread because people evaluate them, recommend them and pass them on. Computer viruses spread solely because they embody the coded instructions: ``Spread me.'' Scientific ideas, like all memes, are subject to a kind of natural selection, and this might look superficially virus-like. But the selective forces that scrutinize scientific ideas are not arbitrary and capricious. They are exacting, well-honed rules, and they do not favor pointless self-serving behavior. They favor all the virtues laid out in textbooks of standard methodology: testability, evidential support, precision, quantifiability, consistency, intersubjectivity, repeatability, universality, progressiveness, independence of cultural milieu, and so on. Faith spreads despite a total lack of every single one of these virtues.

You may find elements of epidemiology in the spread of scientific ideas, but it will be largely descriptive epidemiology. The rapid spread of a good idea through the scientific community may even look like a description of a measles epidemic. But when you examine the underlying reasons you find that they are good ones, satisfying the demanding standards of scientific method. In the history of the spread of faith you will find little else but epidemiology, and causal epidemiology at that. The reason why person A believes one thing and B believes another is simply and solely that A was born on one continent and B on another. Testability, evidential support and the rest aren't even remotely considered. For scientific belief, epidemiology merely comes along afterwards and describes the history of its acceptance. For religious belief, epidemiology is the root cause.

5 Epilogue

Happily, viruses don't win every time. Many children emerge unscathed from the worst that nuns and mullahs can throw at them. Anthony Kenny's own story has a happy ending. He eventually renounced his orders because he could no longer tolerate the obvious contradictions within Catholic belief, and he is now a highly respected scholar. But one cannot help remarking that it must be a powerful infection indeed that took a man of his wisdom and intelligence --- President of the British Academy, no less --- three decades to fight off. Am I unduly alarmist to fear for the soul of my six-year-old innocent?

Acknowledgement

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Religion's misguided missiles

Promise a young man that death is not the end and he will willingly cause disaster

The following Richard Dawkins essay appeared in the popular U.K. news website,The Guardian on September 15, 2001, four days after the World Trade Center terrorist attack.

A guided missile corrects its trajectory as it flies, homing in, say, on the heat of a jet plane's exhaust. A great improvement on a simple ballistic shell, it still cannot discriminate particular targets. It could not zero in on a designated New York skyscraper if launched from as far away as Boston.

That is precisely what a modern "smart missile" can do. Computer miniaturisation has advanced to the point where one of today's smart missiles could be programmed with an image of the Manhattan skyline together with instructions to home in on the north tower of the World Trade Centre. Smart missiles of this sophistication are possessed by the United States, as we learned in the Gulf war, but they are economically beyond ordinary terrorists and scientifically beyond theocratic governments. Might there be a cheaper and easier alternative?

In the second world war, before electronics became cheap and miniature, the psychologist BF Skinner did some research on pigeon-guided missiles. The pigeon was to sit in a tiny cockpit, having previously been trained to peck keys in such a way as to keep a designated target in the centre of a screen. In the missile, the target would be for real.

The principle worked, although it was never put into practice by the US authorities. Even factoring in the costs of training them, pigeons are cheaper and lighter than computers of comparable effectiveness. Their feats in Skinner's boxes suggest that a pigeon, after a regimen of training with colour slides, really could guide a missile to a distinctive landmark at the southern end of Manhattan island. The pigeon has no idea that it is guiding a missile. It just keeps on pecking at those two tall rectangles on the screen, from time to time a food reward drops out of the dispenser, and this goes on until... oblivion.

Pigeons may be cheap and disposable as on-board guidance systems, but there's no escaping the cost of the missile itself. And no such missile large enough to do much damage could penetrate US air space without being intercepted. What is needed is a missile that is not recognised for what it is until too late. Something like a large civilian airliner, carrying the innocuous markings of a well-known carrier and a great deal of fuel. That's the easy part. But how do you smuggle on board the necessary guidance system? You can hardly expect the pilots to surrender the left-hand seat to a pigeon or a computer.

How about using humans as on-board guidance systems, instead of pigeons? Humans are at least as numerous as pigeons, their brains are not significantly costlier than pigeon brains, and for many tasks they are actually superior. Humans have a proven track record in taking over planes by the use of threats, which work because the legitimate pilots value their own lives and those of their passengers.

The natural assumption that the hijacker ultimately values his own life too, and will act rationally to preserve it, leads air crews and ground staff to make calculated decisions that

would not work with guidance modules lacking a sense of self-preservation. If your plane is being hijacked by an armed man who, though prepared to take risks, presumably wants to go on living, there is room for bargaining. A rational pilot complies with the hijacker's wishes, gets the plane down on the ground, has hot food sent in for the passengers and leaves the negotiations to people trained to negotiate.

The problem with the human guidance system is precisely this. Unlike the pigeon version, it knows that a successful mission culminates in its own destruction. Could we develop a biological guidance system with the compliance and dispensability of a pigeon but with a man's resourcefulness and ability to infiltrate plausibly? What we need, in a nutshell, is a human who doesn't mind being blown up. He'd make the perfect on-board guidance system. But suicide enthusiasts are hard to find. Even terminal cancer patients might lose their nerve when the crash was actually looming.

Could we get some otherwise normal humans and somehow persuade them that they are not going to die as a consequence of flying a plane smack into a skyscraper? If only! Nobody is that stupid, but how about this - it's a long shot, but it just might work. Given that they are certainly going to die, couldn't we sucker them into believing that they are going to come to life again afterwards? Don't be daft! No, listen, it might work. Offer them a fast track to a Great Oasis in the Sky, cooled by everlasting fountains. Harps and wings wouldn't appeal to the sort of young men we need, so tell them there's a special martyr's reward of 72 virgin brides, guaranteed eager and exclusive.

Would they fall for it? Yes, testosterone-sodden young men too unattractive to get a woman in this world might be desperate enough to go for 72 private virgins in the next.

It's a tall story, but worth a try. You'd have to get them young, though. Feed them a complete and self-consistent background mythology to make the big lie sound plausible when it comes. Give them a holy book and make them learn it by heart. Do you know, I really think it might work. As luck would have it, we have just the thing to hand: a ready-made system of mind-control which has been honed over centuries, handed down through generations. Millions of people have been brought up in it. It is called religion and, for reasons which one day we may understand, most people fall for it (nowhere more so than America itself, though the irony passes unnoticed). Now all we need is to round up a few of these faith-heads and give them flying lessons.

Facetious? Trivialising an unspeakable evil? That is the exact opposite of my intention, which is deadly serious and prompted by deep grief and fierce anger. I am trying to call attention to the elephant in the room that everybody is too polite - or too devout - to notice: religion, and specifically the devaluing effect that religion has on human life. I don't mean devaluing the life of others (though it can do that too), but devaluing one's own life. Religion teaches the dangerous nonsense that death is not the end.

If death is final, a rational agent can be expected to value his life highly and be reluctant to risk it. This makes the world a safer place, just as a plane is safer if its hijacker wants to survive. At the other extreme, if a significant number of people convince themselves, or are convinced by their priests, that a martyr's death is equivalent to pressing the hyperspace button and zooming through a wormhole to another universe, it can make the world a very dangerous place. Especially if they also believe that that other universe is a paradisical

escape from the tribulations of the real world. Top it off with sincerely believed, if ludicrous and degrading to women, sexual promises, and is it any wonder that naive and frustrated young men are clamouring to be selected for suicide missions?

There is no doubt that the afterlife-obsessed suicidal brain really is a weapon of immense power and danger. It is comparable to a smart missile, and its guidance system is in many respects superior to the most sophisticated electronic brain that money can buy. Yet to a cynical government, organisation, or priesthood, it is very very cheap.

Our leaders have described the recent atrocity with the customary cliche: mindless cowardice. "Mindless" may be a suitable word for the vandalising of a telephone box. It is not helpful for understanding what hit New York on September 11. Those people were not mindless and they were certainly not cowards. On the contrary, they had sufficiently effective minds braced with an insane courage, and it would pay us mightily to understand where that courage came from.

It came from religion. Religion is also, of course, the underlying source of the divisiveness in the Middle East which motivated the use of this deadly weapon in the first place. But that is another story and not my concern here. My concern here is with the weapon itself. To fill a world with religion, or religions of the Abrahamic kind, is like littering the streets with loaded guns. Do not be surprised if they are used.

Interview with Richard Dawkins

Preliminaries

Between 13 August 1995 and 26 August 1995 Steven Carr posted the transcript of a 1994 Channel-4 (U.K.) interview with biologist Richard Dawkins to the Usenet newsgroup alt.atheism.moderated. With Steven's permission, I have made the postings available here. I have combined Steven's multiple postings into one document, made some formatting changes, deleted Steven's comments, fixed typos, and changed some British spellings to American ones.

In my opinion, Dawkins was as provocative and clear in his statements as ever, and I cannot but agree with what he says. Not surprisingly, the series of postings generated a mass of crackpot attempts at rationalizations of the concept of God with science and the Universe. In spite of the moderation, the signal-to-noise ratio in alt.atheism.moderated quickly plummeted to zero.

Feedback: If you have questions or comments regarding the HTML formatting, please send them to me at krishna_kunchith@hotmail.com. If you have any questions about the interview or transcription, direct them at Steven Carr. If you have comments about the contents of the interview, mail Richard Dawkins at Oxford.

Enjoy.

Krishna.

Introduction

Channel 4 in the UK ran a half-hour series of interviews in 1994 called The Vision Thing. Various people with different beliefs were interviewed by Sheena McDonald, a respected TV journalist. The only atheist viewpoint was put by Richard Dawkins on 15 Aug. 1994.

The views expressed do not necessarily agree with mine. This is not just the usual disclaimer.

Note that throughout the interview Sheena McDonald had a half-smile on her face as if to say "Well, these are strange opinions but I suppose I'll have to give them a hearing". She was though, as always, scrupulously fair.

At the time of the interview Richard Dawkins was reader in zoology at the University of Oxford. He is now Professor of Public Understanding of Science at Oxford. He currently has 3 of the top 10 best selling science books in Britain.

Steven Carr.

Interview: Sheena McDonald and Richard Dawkins

McDonald's intro: Imagine no religion! Even non-believers recognize the shock value of John Lennon's lyric. A godless universe is still a shocking idea in most parts of the world. But one English zoologist crusades for his vision of a world of truth, a world without religion, which he says is the enemy of truth, a world which understands the true meaning of life. He's called himself a scientific zealot. In London I met Richard Dawkins.

McDonald: Richard Dawkins, you have a vision of the world---this world free of lies, not the little lies that we protect ourselves with, but what you would see as the big lie, which is that God or some omnipotent creator made and oversees the world. Now, a lot of people are looking for meaning in the world, a lot of them find it through faith. So what's attractive about your godless world, what's beautiful---why would anyone want to live in your world?

Dawkins: The world and the universe is an extremely beautiful place, and the more we understand about it the more beautiful does it appear. It is an immensely exciting experience to be born in the world, born in the universe, and

look around you and realize that before you die you have the opportunity of understanding an immense amount about that world and about that universe and about life and about why we're here. We have the opportunity of understanding far, far more than any of our predecessors ever. That is such an exciting possibility, it would be such a shame to blow it and end your life not having understood what there is to understand.

McDonald: Right, well, let's maximize this opportunity. Paint the world, describe the opportunity that too many of us---you will probably say most of us---are not exploiting to appreciate the world and to understand the world.

Dawkins: Well, suppose you look at an animal such as a human or a hedgehog or a bat, and you really want to understand how it works. The scientific way of understanding how it works would be to treat it rather as an engineer would treat a machine. So if an engineer was handed this television camera that engineer would get a screwdriver out, take it to bits, perhaps try to work out a circuit diagram and try to work out what this thing did, what it was good for, how it works, would explain the functioning of the whole machine in terms of the bits, in terms of the parts.

Then the engineer would probably want to know how it came to be where it was, what's the history of it---was it put together in a factory? Was it sort of suddenly just gelled together spontaneously? Now those are the sorts of questions that a scientist would ask about a bat or a hedgehog or a human, and we've got a long way to go, but a great deal of progress has been made. We really do understand a lot about how we and rats and pigeons work.

I've spoken only of the mechanism of a living thing. There's a whole other set of questions about the history of living things, because each living thing comes into the world through being born or hatched, so you have to ask, where did it get its structure from? It got it largely from its genes. Where do the genes come from? From the parents, the grand-parents, the great-grand parents. You go on back through the history, back through countless generations of history, through fish ancestors, through worm-like ancestors, through protozoa-like ancestors, to bacteria-like ancestors.

McDonald: But the end point of this process would simply be an understanding of the physical world.

Dawkins: What else is there?

McDonald: But to accept your vision, one has to reject what many people hold very dear and close, which is faith. Now, why is faith, why is religious faith incompatible with your vision?

Dawkins: Well, faith as I understand it---you wouldn't bother to use the word faith unless it was being contrasted with some other means of knowing something. So faith to me means knowing something just because you know it's true, rather than because you have seen any evidence that it's true.

McDonald: But if I say I believe in God, you cannot disprove the existence of God.

Dawkins: No, and the virtue of using evidence is precisely that we can come to an agreement about it. But if you listen to two people who are arguing about something, and they each of them have passionate faith that they're right, but they believe different things---they belong to different religions, different faiths, there is nothing they can do to settle their disagreement short of shooting each other, which is what they very often actually do.

McDonald: If religion is an obstacle to understanding what you're saying, why is it getting it wrong?

Dawkins: A creator who created the universe or set up the laws of physics so that life would evolve or who actually supervised the evolution of life, or anything like that, would have to be some sort of super-intelligence, some sort of mega-mind. That mega-mind would have had to be present right at the start of the universe. The whole message of evolution is that complexity and intelligence and all the things that would go with being a creative force come late, they come as a consequence of hundreds of millions of years of natural selection. There was no intelligence early on in the universe. Intelligence arose, it's

arisen here, maybe it's arisen on lots of other places in the universe. Maybe somewhere in some other galaxy there is a super-intelligence so colossal that from our point of view it would be a god. But it cannot have been the sort of God that we need to explain the origin of the universe, because it cannot have been there that early.
McDonald: So religion is peddling a fundamental untruth.
Dawkins: Well, I think it is yes.
McDonald: And there is no possibility of there being something beyond our knowing, beyond your ability as a scientist, zoologist, to [...]
Dawkins: No, that's quite different. I think there's every possibility that there might be something beyond our knowing. All I've said is that I don't think there is any intelligence or any creativity or any purposiveness before the first few hundred million years that the universe has been in existence. So I don't think it's helpful to equate that which we don't understand with God in any sense that is already understood in the existing religions.
The gods that are already understood in existing religions are all thoroughly documented. They do things like forgive sins and impregnate virgins, and they do all sorts of rather ordinary, mundane, human kinds of things. That has nothing whatever to do with the high-flown profound difficulties that science may yet face in understanding the deep problems of the universe.
McDonald: Now a lot of people find great comfort from religion. Not everybody is as you are---well-favored, handsome, wealthy, with a good job, happy family life. I mean, your life is good---not everybody's life is good, and religion brings them comfort.
Dawkins: There are all sorts of things that would be comforting. I expect an injection of morphine would be comforting---it might be more comforting, for all I know. But to say that something is comforting is not to say that it's true.
McDonald: You have rejected religion, and you have written about and posited your own answers to the fundamental questions of life, which are---very crudely, that we and hedgehogs and bats and trees and geckos are driven by genetic and non-genetic replicators. Now instantly I want to know, what does that mean?
Dawkins: Replicators are things that have copies of themselves made. It's a very, very powerful---its' hard to realize what a powerful thing it was when the first self-replicating entity came into the world. Nowadays the most important self-replicating entities we know are DNA molecules; the original ones probably weren't DNA molecules, but they did something similar. Once you've got self-replicating entities---things that make copies of themselves---you get a population of them.
McDonald: In that very raw description that makes us---what makes us us? We're no more than collections of inherited genes each fighting to make its way by the survival of the fittest.
Dawkins: Yes, if you ask me as a poet to say, how do I react to the idea of being a vehicle for DNA? It doesn't sound very romantic, does it? It doesn't sound the sort of vision of life that a poet would have; and I'm quite happy, quite ready to admit that when I'm not thinking about science I'm thinking in a very different way.
It is a very helpful insight to say we are vehicles for our DNA, we are hosts for DNA parasites which are our genes. Those are insights which help us to understand an aspect of life. But it's emotive to say, that's all there is to it, we might as well give up going to Shakespeare plays and give up listening to music and things, because that's got nothing to do with it. That's an entirely different subject.
McDonald: Let's talk about listening to music and going to Shakespeare plays. Now, you coined a word to describe all these various activities which are not genetically driven, and that word is 'meme' and again this is a replicating process.
Dawkins: Yes, there are cultural entities which replicate in something like the same way as DNA does. The spread of the habit of wearing a baseball hat backwards is something that has spread around the Western world like an

epidemic. It's like a smallpox epidemic. You could actually do epidemiology on the reverse baseball hat. It rises to a peak, plateaus and I sincerely hope it will die down soon.

McDonald: What about voting Labour?

Dawkins: Well, you can make---one can take more serious things like that. In a way, I'd rather not get into that, because I think there are better reasons for voting Labour than just slavish imitation of what other people do. Wearing a reverse baseball hat---as far as I know, there is no good reason for that. One does it because one sees one's friends do or, and one thinks it looks cool, and that's all. So that really is like a measles epidemic, it really does spread from brain to brain like a virus.

McDonald: So voting intentions you wouldn't put into that bracket. What about religious practices?

Dawkins: Well, that's a better example. It doesn't spread, on the whole, in a horizontal way, like a measles epidemic. It spreads in a vertical way down the generations. But that kind of thing, I think, spreads down the generations because children at a certain age are very vulnerable to suggestion. They tend to believe what they're told, and there are very good reasons for that. It is easy to see in a Darwinian explanation why children should be equipped with brains that believe what adults tell them. After all, they have to learn a language, and learn a lot else from adults. Why wouldn't they believe it if they're told that they have to pray in a certain way? But in particular---let's just rephrase that---if they're told that not only do they have to behave in such a way, but when they grow up it is their duty to pass on the same message to their children.

Now, once you've got that little recipe, that really is a recipe for passing on and on down the generations. It doesn't matter how silly the original instruction is, if you tell it with sufficient conviction to sufficiently young and gullible children such that when they grow up they will pass it on to their children, then it will pass on and it will pass on and it will spread and that could be sufficient explanation.

McDonald: But religion is a very successful meme. I mean, in your own structures the genes that survive---the ones with the most selfish and successful genes presumably have some merit. Now if religion is a meme which has survived over thousands and thousands of years, is it not possible that there is some intrinsic merit in that?

Dawkins: Yes, there is merit in it. If you ask the question, why does any replicating entity survive over the years and the generations, it is because it has merit. But merit to a replicator just means that it's good at replicating. The rabies virus has considerable merit, and the AIDS virus has enormous merit. These things spread very successfully, and natural selection has built into them extremely effective methods of spreading. In the case of the rabies virus it causes its victims to foam at the mouth, and the virus is actually spread in saliva. It causes them to bite and to become aggressive, so they tend to bite other animals, and the saliva gets into them and it gets passed on. This is a very, very successful virus. It has very considerable merit.

In a way the whole message of the meme and gene idea is that merit is defined as goodness at getting itself spread around, goodness at self-replication. That's of course very different from merit as we humans might judge it.

McDonald: You've chosen an analogy there for religion which a lot of them would find rather hurtful---that it's like an AIDS virus, like a rabies virus.

Dawkins: I think it's a very good analogy. I'm sorry if it's hurtful. I'm trying to explain why these things spread; and I think it's like a chain letter. It is the same kind of stick and carrot. It's not, probably, deliberately thought out.

I could write on a piece of paper "Make two copies of this paper and pass them to friends". I could give it to you. You would read it and make two copies and pass them, and they would make 2 copies and it becomes 4 copies, 8, 16 copies. Pretty soon the whole world would be knee-deep in paper. But of course there has

to be some sort of inducement, so I would have to add something like this "If you do not make 2 copies of this bit of paper and pass it on, you will have bad luck, or you will go to hell, or some dreadful misfortune will befall you".
I think if we start with a chain letter and then say, well, the chain letter principle is too simple in itself, but if we then sort of build upon the chain letter principle and look upon more and more sophisticated inducements to pass on the message, we shall have a successful explanation.
McDonald: But that's all it can be, I mean, sophisticated inducements or threats. I was only bothered that a successful meme may invoke something which has not yet been found in your universe by your methods.
Dawkins: The sophisticated inducements can include the B Minor Mass and the St. Matthew Passion. I mean, they're pretty good stuff. They're very sophisticated and very, very beautiful---stained glass windows, Chartres Cathedral, they work and no wonder they work. I mean they're beautifully done, beautifully crafted.
But I think what you're asking is, does the success of religion down the centuries imply that there must be some truth in its claims? I don't think that is necessary at all, because I think there are plenty of other good explanations which do a better job.
McDonald: Does it exasperate you that people find more pleasure and inspiration in Chartres or Beethoven or indeed great mosques than they do in the anatomy of a lizard?
Dawkins: No, not at all. I mean, I think that great artistic experiences---I don't want to downplay them in any way. I think they are very, very great experiences, and scientific understanding is on a par with them.
McDonald: And yet, these great artistic achievements have been impelled by untruths.
Dawkins: Just think how much greater they would have been if they had been impelled by truth.
McDonald: But can the anatomy of a lizard provoke a great choral symphony?
Dawkins: By calling it the anatomy of a lizard, you, as it were, play for laughs. But if you put it another way---let's say, does geological time or does the evolution of life on earth, could that be the inspiration for a great symphony? Well, of course, it could. It would be hard to imagine a more colossal inspiration for a great piece of music or poetry than 2,000 million years of slow, gradual evolutionary change.
McDonald: But ultimately, there's no point beyond the personal celebration of each life, as far as you're able to. We hope that we're not born into a famine queue in central Africa. But that's not sufficient for people. Maybe they want [...]
Dawkins: Look, it may not be [...]
McDonald: But tough, you say [...]
Dawkins:Tough, yes. I don't want to sound callous. I mean, even if I have nothing to offer, that doesn't matter, because that still doesn't mean that what anybody else has to offer therefore has to be true.
McDonald: Indeed, but you care about it.
Dawkins: Yes, I do want to offer something. I just wanted to give as a preamble the point that there may be a vacuum which is left. If religion goes, there may well be a vacuum in important ways in people's psychology, in people's happiness, and I don't claim to be able to fill that vacuum, and that is not what I want to claim to be able to do. I want to find out what's true.
Now, as for what I might have to offer, I've tried to convey the excitement, the exhilaration of getting as complete a picture of the world and the universe in which you live as possible. You have the power to make a pretty good model of the universe in which you live. It's going to be temporary, you're going to die, but it would be the best way you could spend your time in the universe, to understand why you're there and place as accurate model of the universe as you can inside your head. That's what I would like to encourage people to try to do.
I think it's an immensely fulfilling thing to do.
McDonald: And that will be a better world?

Dawkins: It will certainly be a truer world. I mean, people would have a truer view of the world. I think it would probably be a better world. I think people would be less ready to fight each other because so much of the motivation for fighting would have been removed. I think it would be a better world. It would be a better world in the sense that people would be more fulfilled in having a proper understanding of the world instead of a superstitious understanding.
McDonald: So here we are, in your truer world---except we're not, because for the reasons of juvenile gullibility you suggested the religion meme will continue to replicate itself around the world. For ever will it, or will we ever come to your world?
Dawkins: I suspect for a very long time. I don't know about for ever, whatever for ever is. I mean, I think religion has got an awful long time to go yet, certainly in some parts of the world. I find that a rather depressing prospect, but it is probably true.
McDonald: Isn't that to an extent because you've said yourself, what you have to say may not fill the vacuum which would be left if religion were discarded?
Dawkins: I feel no vacuum. I mean, I feel very happy, very fulfilled. I love my life and I love all sorts of aspects of it which have nothing to do with my science. So I don't have a vacuum. I don't feel cold and bleak. I don't think the world is a cold and bleak place. I think the world is a lovely and a friendly place and I enjoy being in it.
McDonald: Do you think about death?
Dawkins: Yes. I mean, it's something which is going to happen to all of us and [...]
McDonald: How do you prepare for death in a world where there isn't a god?
Dawkins: You prepare for it by facing up to the truth, which is that life is what we have and so we had better live our life to the full while we have it, because there is nothing after it. We are very lucky accidents or at least each one of us is---if we hadn't been here, someone else would have been. I take all this to reinforce my view that I am fantastically lucky to be here and so are you, and we ought to use our brief time in the sunlight to maximum effect by trying to understand things and get as full a vision of the world and life as our brains allow us to, which is pretty full.
McDonald: And that is the first duty, right, responsibility, pleasure of man and woman. Christians would say "love God, love your neighbor". You would say "try to understand".
Dawkins: Well, I wouldn't wish to downplay love your neighbor. It would be rather sad if we didn't do that. But, having agreed that we should love our neighbor and all the other things that are embraced by that wee phrase, I think that, yes, understand, understand is a pretty good commandment.

(End of interview)

Sheena McDonald's wrap-up to camera: Richard Dawkins celebrates life before death with infectious enthusiasm. He rejects life after death with---for many---uncomfortable enthusiasm. In doing so he shows the courage of a true zealot, to go on preaching in the face of continuing resistance to a godless universe. It remains to be seen whether the Dawkins meme, his vision of truth, will replicate with the success that the prophets, priests, popes and gurus have enjoyed.

URL: http://www.geocities.com/krishna_kunchith/misc/dawkins.html

No mercy on the violent river of life, - his summary of River out of Eden--The Telegraph May 10, 1995

An exchange between Michael Poole and Richard Dawkins. Posted by Christian Students in Science (CIS). Originally published in Science and Christian Beliefin Vol 6 April 1994 and Vol 7 1995:

No mercy on the violent river of life - An exchange between Michael Poole (Christian Students in Science) and Richard Dawkins

Article in The Telegraph Wednesday May 10th, 1995

Article Adapted from River Out of Eden

CHARLES DARWIN lost his faith with the help of a wasp. "I cannot persuade myself," Darwin wrote, ---that a beneficent and omnipotent God would have designedly created the Ichneumonidae with the express intention of their feeding within the living bodies of caterpillars." Actually, Darwin's gradual loss of faith, which he downplayed for fear of upsetting his devout wife Emma, had more complex causes.

His reference to the Ichneumonidae was aphoristic. The macabre habits to which he referred are shared by their cousins the digger wasps. A female digger wasp not only lays her egg in a caterpillar (or grasshopper or bee) so that her larva can feed on it. According to Fabre she also carefully guides her sting into each ganglion of the prey's central nervous system so as to paralyse it but not kill it. This way, the meat keeps fresh.

It is not known whether the paralysis acts as a general anaesthetic, or if it is like curare in just freezing the victim's ability to move. If the latter, the prey might be aware of being eaten alive from inside, but unable to move a muscle to do anything about it. This sounds savagely cruel but nature is not cruel, only pitilessly indifferent. This is one of the hardest lessons for humans to learn. We cannot accept that things might be neither good nor evil, neither cruel nor kind, but simply indifferent to all suffering, lacking all purpose.

The river of my new book's title is a river of DNA and it flows through time, not space. DNA is the hereditary chemical that characterises every living thing by carrying its genetic specifications. This is a river of information not of bones and tissues: a river of abstract instructions for building bodies, not a river of solid bodies themselves. The information passes through bodies, and affects them, but it is not affected by them on its way through.

Instead of a river of genes, we could equally well speak of a band of good companions marching through geological time. All the genes of one breeding population are, in the long run, companions of each other. In the short run they sit in individual bodies and are temporarily more intimate companions of the other genes that share a body. Genes are the smallest unit of heredity and they survive down the ages only if they are good at building bodies that are good at living and reproducing in the particular wav of life chosen by the species.

But there is more to it than this. To be good at surviving, a gene must be good at working together with the other genes in the same species - the same river. To survive in the long run, a gene must be a good companion. It must do well in the company of, or against the background of, the other genes in the same river. Genes of another species are in a different river. They do not have to get on well together: not in the same sense, anyway, for they do not have to share the same bodies.

The feature that defines a species is that all members of any one species have the same river of genes flowing through them, and all the genes in a species have to be prepared to be good companions of one another. A new species comes into existence when an existing species divides into two. The river of genes forks in time.

From a gene's point of view, speciation, the origin of new species, is the long goodbye. After a brief period of partial separation, the two rivers go their separate ways forever, or until one or other dries extinct into the sand. Secure within the banks of either river, the water is mixed and remixed by sexual recombination. But water never leaps its banks to contaminate the other river.

After a species has divided, the two sets of genes are no longer companions. They no longer meet in the same bodies and they are no longer required to get on well together. There is no longer any intercourse between them - and intercourse here means literally sexual intercourse between their temporary vehicles, their bodies.

When we think of the divide that leads to all the mammals, as opposed to, say, the stream that led to the grey squirrel, it is tempting to imagine something on a grand Mississippi/Missouri scale. The mammal branch we are talking about is, after all, destined to branch and branch and branch again until it produces all the mammals from pigmy shrew to elephant, from moles underground to monkeys atop the canopy.

The mammal branch of the river is destined to feed so many thousands of important trunk waterways, how could it be other than a massive, rolling torrent? But of course this feeling is wrong. When the ancestors of all the modern mammals broke away from those that are not mammals, the event would have seemed no more momentous than any other speciation. It would have gone unremarked by any naturalist who happened to be around at the time. The new branch of the river of genes would have been a trickle, inhabiting a species of little nocturnal creature no more different from its non-mammalian cousins than a red squirrel is different from a grey.

It is only with hindsight that we see the ancestral mammal as a mammal at all. In those days it would have been just another species of mammal-like reptile, not markedly different from perhaps a dozen other small, snouty, insectivorous morsels of dinosaur-food.

Natural selection is concerned only with the narrow present - with the survival of DNA through millions of successive present moments, strung out along millions of branches of the river of DNA. Natural selection is as indifferent to the distant future of the race as it is indifferent to the suffering of the individuals being selected. For, to return to our pessimistic beginning, when the utility function - that which is being maximised - is DNA survival, this is not a recipe for happiness.

If nature were kind, she would at least make the minor concession of anaesthetising caterpillars before they are eaten alive from within. But nature is neither kind nor unkind. She is neither against suffering, nor for it. Nature is not interested in suffering one way or the other unless it affects the survival of DNA.

It is easy to imagine a. gene that, say, tranquillises gazelles when they are about to suffer a killing bite. Would such a gene be favoured by natural selection? Not unless the act of tranquillising a gazelle improved that gene's chances of being propagated into future generations. It is hard to see why this should be so and we may therefore guess that gazelles suffer horrible pain and fear when they are pursued to the death - as most of them eventually are.

The total amount of suffering per year in the natural world is beyond all decent contemplation. During the minute that it takes me to compose this sentence, thousands of animals are being eaten alive, others are running for their lives, whimpering with fear, others are being slowly devoured from within by rasping parasites, thousands of all kinds are dying of starvation, thirst and disease. It must be so.

If there is ever a time of plenty, this very fact will automatically lead to an increase in population until the natural state of starvation and misery is restored. Theologians worry away at the *'Problem of Evil" and a related Problem of Suffering. On the day that 1 originally wrote this paragraph, the newspapers were filled with one of those heartrending disasters, the tragic crash of a busload of children.

Not for the first time, clerics were in paroxysms over the theological question, in the words of The Sunday Telegraph, ---How can you believe in a loving, all-powerful God who allows such a tragedy?"

The paper went on to quote one priest: "The simple answer is that we do not know why there should be a God who lets these awful things happen. But the horror of the crash, to a Christian, confirms the fact that we live in a world of real values: positive and negative. If the universe was just electrons, there would be no problem of evil or suffering.

On the contrary, if the universe were just electrons and selfish genes, meaningless tragedies are exactly what we should expect, along with equally meaningless good fortune. Such a universe would be neither evil nor good in intention. It would manifest no intentions of any kind.

In a universe of blind physical forces and genetic replication, some people are going to get hurt, other people are going to get lucky, and you won't find any rhyme or reason in it, or any justice. The universe that we observe has precisely the properties we should expect if there is, at bottom, no design, no purpose, no evil and no good, nothing but blind, pitiless indifference. As that unhappy poet A E Housman put it:

For Nature, heartless, witless
Nature
Will neither know nor care.

DNA neither knows nor cares. DNA just is. And we dance to its music.

F I Adapted by Dr Dawkins from his book,
River Out of Eden, published on May 18
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A Critique of Aspects of the Philosophy and Theology of Richard Dawkins

Michael Poole

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Pronouncements made by scientists about religion are frequently seen as carrying some special authority. Undue weight may therefore be attached to their views on matters outside of their own fields of expertise. This possibility seemed to be particularly acute during Richard Dawkins' 1991 Royal Institution Christmas Lectures, both on account of the number of antireligious assertions and of the youth of the audience. It is because of the widespread attempts which Dawkins has made to disseminate his personal world - view in the name of science, that a paper examining his claims seems called for. For those unfamiliar with his works, this paper offers a commentary on scientific naturalism.

Keywords: Richard Dawkins, design argument, evolution, explanation, faith, God, language, meaning, meme, metaphor, miracles, purpose, religion, selfish gene, supernatural.

Introduction

Richard Dawkins is Reader in Zoology in the University of Oxford. He has a deservedly high reputation in his field of ethology, and his book The Extended Phenotype has been described by one reviewer as 'a contender for the title of the most important contribution to evolutionary biology in the 1980s'. However, since this book is possibly one of Dawkins' less contentious works so far as the subject of this paper is concerned, it does not feature prominently here.

Dawkins has also made numerous television appearances, major ones including The Blind Watchmaker, BBC 2 Horizon, 19 January 1987 and the 1991 Royal Institution Christmas Lectures, Growing Up in the Universe, broadcast on BBC 2 in December 1991 and repeated one year later.

In addition to his Zoological studies, Dawkins has made frequent excursions into philosophy and theology in his popular writings, on television, in debates and in letters to the press. He has contributed to the science/religion debate by pointing out, along with others, weaknesses in the arguments of those Creationists who claim that evolution cannot account for the development of complex features like the eye. But he has also relentlessly advocated the conflict thesis.

Theology

It might appear odd to speak of the 'theology' of Richard Dawkins on account of his declared aversion to the subject, not least in his letter to The Independent following the announcement of the setting up of the Starbridge Lectureship in Theology and Natural Science at Cambridge.

What has 'theology' ever said that is of the smallest use to anybody? When has 'theology' ever said anything that is demonstrably true and is not obvious? ... What makes you think that 'theology' is a subject at all?

However, Dawkins' position can better be understood by initially clarifying what kind of a god he does not believe in. So the first part of this paper outlines Dawkins' published views on such theological matters as God, faith, miracles, the supernatural, and religion in general. This is followed by more general philosophical considerations about the nature of explanation, reductionism and the use of language. There is of course no sharp dividing line between the theology and the philosophy under review; it all falls beneath the umbrella of philosophical theology.

Religion

Dawkins' view of religion is that it is a scientific theory:

... until recently one of religion's main functions was scientific; the explanation of existence, of the universe, of life ... So the most basic claims of religion are scientific. Religion is a scientific theory. [SCAG - key at end of paper]

Such a claim indicates the need for clarifying (i) the nature of a scientific theory and (ii) the distinctions between the meaningful and valid ways in which terms and criteria for testing truth - claims are used within science and religion. Each of these would be huge tasks in themselves. Some points about the differences between the two disciplines will emerge in what follows, but all that is necessary at this stage is to recognise that Dawkins claims that science and religion are rival explanations of our world, This claim is pivotal to his whole position, making the subject of the nature of explanation central to this paper. But before reaching that section, Dawkins' notion that these types of explanations are in competition will be evident in his views on the intermediate subjects.

God

In accordance with the above, Dawkins sees the 'hypothesis of God' as an explanatory hypothesis which is in competition with evolution by natural selection: 'God and natural selection are, after all, the only two workable theories we have of why we exist.' [EP p. 181] Dawkins' oft - repeated objection to the 'hypothesis of God' is frequently based on the notion of complexity -

... any God capable of intelligently designing something as complex as the DNA/protein replicating machine must have been at least as complex and organised as that machine itself. Far more so if we suppose him additionally capable of such advanced functions as listening to prayers and forgiving sins. To explain the origin of the DNA/protein machine by invoking a supernatural Designer is to explain precisely nothing, for it leaves unexplained the origin of the Designer. [BWM, p. 141]

and also on the concept of probability, for

... any god worthy of the name must have been a being of colossal intelligence, a supermind, an entity of enormous sophistication and complexity. In other words, an entity of extremely low statistical probability - a very improbable being. [SCAG]

This kind of reasoning, culminating in the question 'But who designed the divine creator?' [CLSG, p. ill is repeated in several places [e.g. CL 2]. Dawkins' constant assumption, echoing the popular demand, 'who made God?', is that since our common experience indicates that material objects have beginnings, God would also have had to have had an originator.In that sense, the 'god' in whom Dawkins disbelieves is a 'god' in whom the major world religions, Christianity, Judaism and Islam do not believe either. His assumption is a particularly interesting one from the point of view of consistency of argument, since it is precisely this kind of analogical argument that he so vehemently rejects if applied to the world having a designer by comparison with everyday artifacts having designers.

The supernatural

Again by invoking probability, Dawkins attempts to dismiss events which are claimed to be of supernatural origin. In his Christmas Lectures he assured his youthful audience that

Growing up in the universe. . . also means growing out of parochial and supernatural views of the universe . . . trying to understand how the universe works, not copping out with superstitious ideas that only seem to explain things but actually explain nothing. Well, you might say, can we really afford to be snooty about the supernatural? After all many of us have had uncanny experiences ... [CL 1]

In trying to persuade his audience that there is no substance to supernatural claims Dawkins used an argument which needs to be scrutinised carefully. He asked each of the young people to will the outcome of the tossing of a coin to be heads or tails and for those who got it wrong to sit down. Eight tosses eliminated all but one of the audience.

The 'achievement' of the 'winner' was interpreted thus:

It had to come out, because of the number of people here. It had to come out that somebody was apparently psychic ... he could have thought about ham - and - eggs.

Now when people write into the papers with uncanny experiences, it's just like that, because the circulation of a tabloid paper is up in the millions. There's got to be somebody out there having an amazing experience at this very moment and it means absolutely nothing. So ... whenever you hear a story about uncanny, spooky, telepathic experiences, think about this experiment and think about how likely it would be to come about anyway. [CL 1]

So the argument started off that, given enough people and enough time, even events which are of low probability for any one person are to be expected - and there is of course truth in this claim. Then came the enormous and unjustifiable leap of equating improbable events in the precise calculus of statistical probability - in this case eight consecutive, correct predictions ('willings') of the fall of a coin - with 'uncanny, spooky, telepathic experiences', among which Dawkins would presumably include answered prayer.

In similar vein Dawkins warned that 'growing up - in the sense of achieving a grown - up understanding of the universe' [CL 5] carries dangers of self deception, for

... each of those mental tools - imagination, language and technology is double edged ... A brain that's good at simulating models in imagination - things that aren't there - is unfortunately, also, almost inevitably in danger of self - delusion ... if ever we hear a story that somebody has seen a vision, been visited by an archangel, heard voices in his head, we should be immediately suspicious. [CL 5]

Although we were not told why we should be immediately suspicious, the implication was that all these things are illusory and will eventually be displaced by a better understanding of science:

As time goes by and our civilisation grows up more, the model of the universe that we share will become progressively less superstitious, less small - minded, less parochial. It will lose its remaining ghosts, hobgoblins and spirits, it will be a realistic model, correctly regulated and updated by incoming information from the real world. [CL 5]

Blame for children retaining 'superstitious' ideas about God is laid upon schools and upon parents:

Most people, I believe, think that you need a god to explain the existence of the world, and especially the existence of life. They are wrong, but our education system is such that many people don't know it. [SCAG]

Children of a certain age believe what they're told. Father Christmas and tooth fairies are harmless enough. But a mind that's capable of believing in fairies is a mind that's vulnerable to all manner of other stuff. [CL 5]

How much of what we believe about our world is the result of what we have been conditioned or told to think? To what extent are we influenced by our parents and our surroundings? Or do we believe what we believe because we have actually and quite independently thought it through? [CLSG, p. 27]

But presumably Dawkins would not direct such criticisms against parents who taught their children that there is no God and insisted that answers to the question '. . . what is life and what, if anything, is it for?' can only be provided, as Dawkins claims, by 'science'. [CL 1] Also, in keeping with the sentiments expressed in the last quotation, would Dawkins commend children who, although reared by atheist parents, came to believe in God after having 'quite independently thought it through'?

Miracles

The notion of probability is once more invoked over the concept of miracle, which is lumped together with 'Chance, luck, coincidence'.

> ... events that we commonly call miracles are not supernatural, but are part of a spectrum of more - or - less improbable natural events. A miracle, in other words, if it occurs at all, is a tremendous stroke of luck. Events don't fall neatly into natural events versus miracles. [BWM, p. 139]

To regard miracles simply as events of very low probability may reflect one popular use of the word 'miracle' - to describe for example the unlikely event of somebody surviving a mid - air collision - but, apart from the rarity aspect, it has little to do with any biblical concept of miracle. For such events are usually associated with the agency of God, carrying with them the idea of a sign. Wonder, significance and (usually) divine agency are all involved; they are not just 'more - or - less improbable natural events'. Dawkins' free use of 'improbable' does however raise questions about his use of the notion of 'probability'. What does he mean by calling God 'a very improbable being', or by saying: 'There's got to be [i.e. probable to the point of certainty] somebody out there having an amazing experience at this very moment' or indeed 'miracles . . . are part of a spectrum of more - or - less improbable natural events'? For Dawkins does not explicate the meanings he assigns to the term 'probability'. Is it simply a subjective expression of confidence? Is it a judgement based on calculation from probabilities calculated on some supposedly a priori grounds? Or is it a mathematical relationship? In the coin - tossing exercise, but certainly not with 'uncanny, spooky, telepathic experiences', the meaning of probability is precise, being the ratio of the number of ways in which something happens - eight consecutive heads uppermost - to the number of ways in which something could happen, which is 28, i.e. a probability of 1:256. But a long run frequency theory of probability is hardly applicable to God. Neither can it validly be applied to an 'amazing experience', when each one is unique (unlike the binary outcomes of coin - tossing) and each must be judged separately for its worth. There is no way of assigning mathematical probabilities to unique events.

Faith

> Faith is the great cop - out, the great excuse to evade the need to think and evaluate evidence. Faith is belief in spite of, even perhaps because of the lack of evidence ... Faith is not allowed to justify itself by argument. [SCAG]

Similar assertions appear on pp. 196ff SG and pp. 330f SG. 'Faith' religious faith that is - is taken by Dawkins to be unevidenced belief. It is not clear what he means by 'because of, the lack of evidence', but there is a perfectly unambiguous word already in the English language for unevidenced belief or for beliefs which are actually contradicted by the evidence, and that is credulity. Dawkins' indiscriminate use of the word 'faith' is confusing since the word is not univocal. While disparaging faith in religious usage, Dawkins uses faith with approval in another context:

> Put your trust in the scientific method. Put your faith in the scientific method, There's nothing wrong with having faith . . . there's nothing wrong with having faith in a proper scientific prediction. [CL 1]

In addition to portraying 'faith' - used in a religious sense as unevidenced belief, Dawkins also depicts it as voluntaristic in character, devoid of substance, reflecting only the 'will to believe'. So he dismisses some Creationists' claims that the Paluxy River 'footprints' show that humans and dinosaurs were around at the same time, saying

> they saw it because they wanted to see it. They believed it because it fitted with their world - view. They were blind to the truth that was staring them in the face. [BWM TV]

But this is a bad argument for rejecting anyone's views, for it tells us nothing about the truth or falsity of what they believe. One can both want to believe something and it can be true. The grounds for rejecting this particular claim are provided by geological and other evidence, not by whether anyone wished or did not wish to believe it. The difficulty about charging others with wishful thinking is that it is to use a double - edged sword, one which can be wielded equally well against those who believe that there is no God. Such a view of religious faith as voluntaristic, unevidenced belief stands in stark contrast to that expressed in the closing paragraph of F. F. Bruce's The New Testament Documents:

The earliest propagators of Christianity welcomed the fullest examination of the credentials of their message. The events which they proclaimed were, as Paul said to King Agrippa, not done in a corner, and were well able to bear all the light that could be thrown on them. The spirit of these early Christians ought to animate their modem descendants. For by an acquaintance with the relevant evidence they will not only be able to give to everyone who asks them a reason for the hope that is in them, but they themselves, like Theophilus, will thus know more accurately how secure is the basis of the faith which the now more accurately how secure is the basis of the faith which they have been taught.

Christian faith is grounded on a combination of evidence, including that drawn from history, personal experience and the world around. The justification for such belief is, as Mitchell has argued, "in the nature of a cumulative case. Like the clues in a detective story, no individual items of evidence may be totally compelling on their own, but together they may build up a convincing case, sufficient for action."

Dawkins conducts a further foray against faith as '...capable of driving people to such dangerous folly that faith seems to me to qualify as a kind of mental illness... powerful enough to immunize people against all appeals to pity, to forgiveness, to decent human feelings.' [pp. 330f SG] The argument is a tired one. While acknowledging the atrocities that have been committed - supposedly in the name of God - and heeding the criterion of Jesus for distinguishing between the genuine and the bogus, that 'by their fruit you will recognise them' (Matt 7:15 - 23), it simply will not do to dismiss religious faith in this way. It is superfluous to list the noble deeds of the faithful. The bad argument can be highlighted by pointing out that some of the most evil deeds committed have been occasioned by sexual desire. But this is hardly a good reason for avoiding sexual activity. Right use, not disuse, is the antidote to misuse.

To summarise so far, on theological matters Dawkins treats the concept of God as that of a created being; faith as unevidenced belief; and miracles simply as 'more - or - less improbable natural events'. Confusion is inevitable since the words 'God', 'faith' and 'miracle' are the same words which Christians already use; and the meanings assigned to them by Dawkins are so different from biblical thought that they become a kind of theological 'Newspeak'.

Explanation

A major, probably the major, philosophical difficulty encountered Dawkins comments about religion is the equivocal way in which he uses the word 'explanation'. Take for example the following assertion:

The only thing he [Paley] got wrong - admittedly quite a big thing - was the explanation itself. He gave the traditional religious answer to the riddle, but he articulated it more clearly and convincingly than anybody had before. The true explanation is utterly different, and it had to wait for one of the most revolutionary thinkers of all time, Charles Darwin. [BWM, p. 41]

Now if all that Dawkins meant by this was that Paley's idea of separate creations was wrong in view of current understanding of the origin of species, the statement could pass without comment. But it is his claim in many different places that religious explanations are displaced by scientific ones which is open to criticism. His naturalistic position only admits physical explanations:

The kind of explanation we come up with must not contradict the laws of physics. Indeed it will make use of the laws of physics, an nothing more than the laws of physics. [BWM, p. 151]

Of course if the required explanation is a scientific one, the statement is unobjectionable. But there appears to be no acknowledgement, in any the writings of Dawkins which I have consulted, that religious explanation in terms of the actions of a divine agent are logically compatible with scientific explanations of the mechanisms of the processes involved. The concept of explanation is more multifaceted than Dawkins appears to recognise. To explain something is to make it plain and there are various ways of doing this. The literature on the nature of explanation is vast, but Brown and Atkins have set out a simple analysis of the concept:

Our typology consists of three main types of explanation. These may be labelled the Interpretive, the Descriptive and the Reason - Giving. They approximate to the questions, What?, How?, and Why? Interpretive explanations interpret or clarify an issue or specify the central meaning of a term or statement ... Descriptive explanations describe processes structure and procedures ... Reason - giving explanations involve giving reasons based on principles or generalisations, motives, obligations values.

So, typically, an object such as a thermostat might have a number of compatible explanations:
An interpretive explanation
A thermostat is a device for maintaining a constant temperature.
A descriptive explanation
A (particular) thermostat consists of a bimetallic strip in close proximity to an electrical contact.
A reason - giving (scientific)
explanation Constant temperature is maintained because, when the temperature falls, the bimetal strip bends so making electrical contact. It switches on a heater which operates until at a predetermined temperature, the bimetal strip bends away from the contact, thereby breaking the circuit.
A reason - giving (motives)
explanation An agent wished to be able to maintain enclosures at constant temperatures to enable people to work comfortably, ovens to cook evenly, and chickens to hatch successfully.

It is with the reason - giving explanations that our concerns lie. For it needs to be understood that there is no logical conflict between reason - giving explanations which concern mechanisms, and reason - giving explanations which concern the plans and purposes of an agent, human or divine. This is a logical point, not a matter of whether one does or does not happen to believe in God oneself. For it is an invalid reason for rejecting the concept of a divine creator, that we understand how the world came into being. But this point is one which Dawkins consistently overlooks. He fails to acknowledge that there is no logical contradiction between the claim that living things are the outcome of evolution by natural selection and that they could also be the outcome of the plan and purposes of an agent God.

Dawkins' argument that 'Evolution starts from simple beginnings ... We don't have to start with a complicated thing like a creator.' [CL 2] might have some force if God's agency was indeed an explanation of the same type as a scientific explanation, in view of Ockham's principle that 'It is vain to do with more what can be done with fewer'. But the explanations are of different types, and the philosopher and theologian William of Ockham certainly did not mean that theological explanations were displaced by explanations of mechanisms! So in collapsing the distinction between these two type of explanations and treating them as alternatives, Dawkins is committing a type error in explanation. In fact he is making the classic explanatory type - error - Coulson's ubiquitous 'God - of - the - gaps' which accords 'god' the status of being the same type of explanation as a scientific one, one which can be 'plugged in' to the gaps which science is not yet able to fill. So, working from the erroneous belief that the God in whom Christians and others believe is a God - of - the - gaps, Dawkins' task must be to fill the gaps with scientific explanations on the further mistaken belief that they have replacement status for God. On this misconception, the gaps, being filled or capable of being filled, means that you do not 'need a god to explain the existence of the world, and especially the existence of life'.

There are of course very good reasons for trying to fill in the gaps. Coulson, who coined the phrase 'God - of - the - gaps', wisely recommended out of his Christian convictions that, 'When we come to the scientifically unknown, our correct policy is not to rejoice because we have found God; it is to become better scientists. For the scientific enterprise is based on a belief that gaps can be filled - but with scientific explanations, not with talk 'about' God. So there is a restricted sense in which it is true to say that science has no need for God, that talk about God is unnecessary in science. Its practitioners have chosen to confine science to physical observables and consequently talk about God forms no part of a scientific explanation. But that does not justify any scientist in claiming that the methodological decision to be silent about God means that science has disproved God!

Reductionism

Reductionism also belongs under the canopy of explanation and it needs to be distinguished in its various forms. Using Ayala's nomenclature, there is the theologically benign methodological reductionism which is simply one of the standard scientific procedures of reducing things to their component parts for study. Within this framework Dawkins' methodological approach fits comfortably:

For those who like 'ism' sorts of names, the aptest name for my approach to understanding how things work is probably 'hierarchical reductionism'. If you read trendy intellectual magazines, you may have noticed that 'reductionism' is one of those things, like sin, that is only mentioned by people who are against it . . . . The nonexistent reductionist - the sort that everybody is against, but who exists only in their imaginations - tries to explain complicated things directly in terms of the smallest part, even, in some extremes of the myth, as the sum of the parts! The hierarchical reductionist, on the other hand, explains a complex entity at any particular level in the hierarchy of organization, in terms of entities only one level down the hierarchy; entities which, themselves, are likely to be complex enough to need further reducing to their own component parts; and so on. [BWM, p. 13]

He illustrates his position by reference to the components of a car. However, from his naturalistic stance Dawkins also espouses reductionism in its second form of ontological reductionism [ontology: the study of existence, of being]. In denying God and the supernatural, Dawkins expresses his belief that the material is all that there is. Ontological reductionism, commonly abbreviated to reductionism and dubbed by MacKay as 'nothing buttery', 'is taken to imply that religion is just psychology, psychology is basically biology, biology is the chemistry of large molecules, whose atoms obey the laws of physics, which will ultimately account for everything!' The difficulty about any attempt to justify a dogmatic assertion that the material is all that exists, is that it would require some privileged insight into the way things actually are, in order to know whether it is true or not.
Design

The 'Argument from Design' in its best known form was expounded by the eighteenth - century theologian William Paley. Dawkins confesses an admiration for Paley. for his 'passionate sincerity,' even though he regards his solution as 'wrong, gloriously and utterly wrong. The analogy between telescope and eye, between watch and living organism, is false.' [BWM, p. 5] Dawkins is of course correct in recognising a philosophical weakness in one of the traditional 'proofs' of the existence of God - the Argument from Design. But there is more to be said about the matter of design than this. Dawkins allows that the natural world looks as though it has been designed and rightly attributes this to our experience of many complex and purposeful things which have been designed. But he then goes on to claim that, since the mechanism of chance variations + natural selection can account for the outcome of complexity, divine agency cannot be involved, whereas such an account neither proves nor disproves God's activity.

Living objects ... look designed, they look overwhelmingly as though they're designed. But it's terribly, terribly tempting to use the word designed. Time and time again I have to bite my tongue and stop myself saying, for example, that this swift is designed for rapid, high speed, highly manoeuverable flight and, as a matter of fact, when talking to other biologists, we none of us bother to bite our tongues. We just use the word designed. But I've told you that they are not designed and coined the special word 'designoid'. . . [CL 2]

This [appearance of design] is probably the most powerful reason for the belief, held by the vast majority of people that have ever lived, in some kind of supernatural deity. It took a very great leap of the imagination for Darwin and Wallace to see that, contrary to all intuition, there is another way and, once you have understood it, a far more plausible way, for complex 'design' to arise out of primeval simplicity. [BWM, p. xiij

Once again the underlying muddle over the nature of explanation has surfaced. Dawkins takes the existence of a mechanism accounting for adaptation as a reason for dismissing any idea of design. But the reason is baseless. The existence of evolutionary mechanisms modifies the form of Paley's claims, but it does not eliminate all idea of design. For instance, one argument favoured by Darwin was that the laws of nature were themselves designed. Charles Kingsley found it 'just as noble a conception of Deity, to believe that He created primal forms capable of self development ... as to believe that He required a fresh act of intervention to supply the lacunas [gaps, missing parts] which He Himself had made. Indeed it could be argued that evolution by natural selection is a clever way of ensuring that available ecological niches are occupied; and that if climate and food supplies change, provided the changes are not too rapid, populations of living things are likely gradually to adapt to these changes, rather than dying out. In fact, Frederick Temple, in his 1884 Bampton Lectures made the point that

What is touched by this doctrine [of Evolution] is not the evidence of design but the mode in which the design was executed.. . In the one case the Creator made the animals at once such as they now are; in the other case He impressed on certain particles of matter ... such inherent powers that in the ordinary course of time living creatures such as the present were developed ... He did not make the things, we may say; no, but

He made them make themselves.

The fact that the processes can be described - as Dawkins does - by words like automatic, does not eliminate any idea of divine agency. It is all very well to say that

A designoid object is an object that LOOKS good enough for it to have been designed, but which in fact has grown up by an entirely different process, an automatic, unguided and wholly unthought - out process. [CLSG, p. 11]

- but 'automatic' is not a word which entails 'unguided and wholly unthought - out'. In the second Gospel, Mark himself uses it:

A man scatters seed on the ground ... the seed sprouts and grows, though he does not know how. All by itself [automatos - Eng. automatic] the soil produces corn - first the stalk, then the ear, then the full grain in the ear. [4:2 7f, NIV]

As to whether processes which involve chance/random events + selection of some kind can be seen as divinely managed depends to some extent on the meanings attached to the words chance and random, something which is outside of the scope of this paper. Suffice to say that the technical meanings of these two terms carry no metaphysical overtones. Indeed, Bartholomew, Peacocke and others have argued that God can create through the operation of what we call chance, within a lawlike framework. But Dawkins does not appear to recognise that the two ideas of processes and agency are logically compatible. Yet, in an almost throwaway comment in the second of the Christmas Lectures, he appears to undermine his whole position of claiming that the processes of chance + selection are incompatible with the actions of an intelligent agent. For he referred en passant to the work of 'Ingo Rechenberg from Germany ... [who] designs windmills and he claims that he designs his windmills by a kind of natural selection.' [CL 2] In the TV programme, The Blind Watchmaker, Dawkins elaborated slightly on Rechenberg's 'evolution' of ideal shapes for aerofoil sections which minimise drag, and referred to the process as 'Darwinian design'.

Rechenberg's book 'Evolutionstrategie' Optimierung Technischer Systeme Nach Prinzipien der Biologischen Evolution, (Stuttgart: Fromman - Holzboog, 1973), is not, as far as I know, translated into English but, 'optimising technical systems according to the principles of biological evolution' presumably involves randomising certain key parameters and then selecting aerofoil sections according to desired outcomes. This double process of chance + selection is employed by a purposive, intelligent agent. So too is Dawkins' fascinating computer programme, Biomorphs planned by a purposive, intelligent agent - in this case the purpose being to illustrate evolution by natural selection. So any claim that chance/random variations + selection is necessarily incompatible with the actions of an intelligent, purposive agent, human or divine, is falsified by exemplars like these. Perhaps this is what a certain commentator on The Blind Watchmaker had in mind when he referred to Dawkins as The Blind Biomorphmaker.

Language & metaphor

One use of language which in a subtle way promotes the naturalistic view which Dawkins wishes to advance is the reification of concepts like nature, evolution, natural selection and chance. Following in a long naturalistic tradition, exemplified by T. H. Huxley with his 'Dame Nature', concepts like these are often vested with attributes formerly ascribed to God and misleadingly credited with the abilities to 'choose', 'build', 'manufacture' and 'create' as in the following passages [italics are mine]:

Natural selection is like artificial selection, except that, instead of humans doing the choosing, nature does the choosing ... Natural selection, nature, is constantly choosing which individuals shall live, which individuals shall breed [CL2]

So am I really trying to persuade you that a blind, unconscious process, evolution, can build animal optics that rival human technology? ...but evolution, the blind designer, using cumulative trial and error, can search the vast space of possible structures ... blind chance on its own is no kind of watchmaker. But chance with natural selection, chance smeared out into innumerable tiny steps over aeons of time is powerful enough to manufacture miracles like dinosaurs and ourselves ... yet we evolutionists seem to be saying that it [the eye] was created by blind chance ... [BWM TV]

There is of course a sense in which the use of words in this way could be regarded as a legitimate literary device, on a par with 'Old Mother Nature' stories for children. Indeed, in Dawkins' defence it might be argued that he uses the words as such a literary device, since he makes the following disclaimer:

Natural selection, the blind, unconscious, automatic process which Darwin discovered, and which we now know is the explanation for the existence and apparently purposeful form of all life, has no purpose in mind. It has no mind and no mind's eye. It does not plan for the future. It has no vision, no foresight, no sight at all. If it can be said to play the role of watchmaker in nature, it is the blind watchmaker. [BWM, p. 5]

But the frequent use of the word 'blind', with its implication of absence of divine activity, indicates that Dawkins' intentions go further than the employment of a metaphysically - neutral literary device. Instead, the charge must be one of inconsistency; for if his statement immediately above stands, then many of his other assertions are highly misleading and need to be rewritten. The literary device is not legitimate if the purpose of such usage is to press the thesis that science obviates God. Such use of these words degenerates into nonsense if a creating God is denied while a creating chance (+ natural selection) is affirmed. Such Tychism will not do.

Further to Dawkins' use of metaphor, his expression, the selfish gene has attracted considerable attention. He offers his justification for the term - and his caveats against misunderstanding - in the following ways:

If we allow ourselves the licence of talking about genes as if they had conscious aims, always reassuring ourselves that we could translate our sloppy language back into respectable terms if we wanted to, we can ask the question, what is a single selfish gene trying to do? [SG, p. 88]

The metaphor of the intelligent gene reckoning up how best to ensure its own survival ... is a powerful and illuminating one. But it is easy to get carried away, and allow hypothetical genes cognitive wisdom and foresight in planning their 'strategy'. [EP, p. 15]

Dawkins has been criticised for his use of the 'selfish' metaphor. One series of 'full and frank' exchanges is found in three issues of Philosophy. Midgley criticises the metaphor in 'Gene - juggling'' Dawkins responds in 'In Defence of Selfish Genes' [IDSG] and Midgley replies in 'Selfish Genes and Social Darwinism'.

Midgley's first article is decidedly polemical. She apologises in her second one for the tone of her criticisms and sets out in more measured form the difficulties which she sees as still remaining from the exchange of views. In response to Midgley's criticism of his use of the word 'selfish', Dawkins says

When biologists talk about 'selfishness' or 'altruism' we . . . do not even mean the words in a metaphorical sense. We define altruism and selfishness in purely behaviouristic ways ... I assume that an oak tree has no emotions and cannot calculate, yet I might describe an oak tree as altruistic if it grew fewer leaves than its physiological optimum, thereby sparing neighbouring saplings harmful overshadowing ... words may be redefined for technical purposes. In effect I am saying: 'Provided I define selfishness in a particular way an oak tree, or a gene, may legitimately be described as selfish'. [IDSG p. 557]

But despite the disclaimer, the phrase 'selfish gene' is metaphorical since 'a word or phrase denoting one kind of object or action is used in place of another to suggest a likeness or analogy between them'. Stipulative definitions are, of course, legitimate explanatory devices. Their value, however, depends on their power to clarify rather than to confuse. But 'selfish', as Midgley points out has such a common meaning that

It is by no means enough, in such cases, simply to give a new definition and repeat it from time to time. When a term is drawn from everyday speech like this, the force of habitual usage is far too strong for that.

Selfish, then, means here something like 'actually self - preserving in the long run' . . . It is true that philosophers are used to special technical definitions. But that does not mean that no standards apply to their manufacture.

A restricted sense ought to be one which forms part of the normal meaning of the word. It cannot be one which falls, as this does, right outside it ... the question 'why say selfish rather than self - preserving or self - replicating or self - perpetuating or competitive or the like?' is still serious.

Memes

The 'selfish' metaphor is pursued in Dawkins' concept of the 'meme', an entity which he introduces in the following way and amplifies in EP, p. 109.

I think that a new kind of replicator has recently emerged on this very planet ... but already it is achieving evolutionary change at a rate that leaves the old gene panting far behind ... We need a name for the new Replicator ... meme . . . .

Examples of memes are tunes, catch - phrases, clothes fashions, ways of making pots or of building arches. just as genes propagate themselves in the gene pool by leaping from body to body via sperm or eggs, so memes propagate themselves in the meme pool by leaping from brain to brain ... [SG, p. 192]

As with genes, the qualities that give rise to high survival value among memes are given as 'longevity, fecundity, and copying - fidelity' [SG p. 194]. The idea of the meme is an interesting one but its noteworthiness in the context of this paper lies in how it is employed. For most of the developed examples of 'memes' on pp. 192 - 9 [SG] are ones which are used to convey highly negative images of religion. They include (i) the 'god meme'(ii) the 'hell fire' meme and (iii) a 'member of the religious meme complex [which] is called faith':

[i] The survival value of the god meme in the meme pool results from its great psychological appeal. It provides a superficially plausible answer to deep and troubling questions about existence. It suggests that injustices in this world may be rectified in the next. The 'everlasting arms' hold out a cushion against our own inadequacies which, like a doctor's placebo, is none the less effective for being imaginary. [SG p. 1931

[ii] We have even used words like 'selfish' and 'ruthless' of genes, knowing full well it is only a figure of speech. Can we, in exactly the same spirit, look for selfish or ruthless memes? ... To take a particular example, an aspect of doctrine that has been very effective in enforcing religious observance is the threat of hell fire ...

[iii] [faith] means blind trust, in the absence of evidence, even in the teeth of evidence ... The meme for blind faith secures its own perpetuation by the simple unconscious expedient of discouraging rational enquiry.

Dawkins displays a wholly instrumentalist view of the concepts of God, hell and faith. Erroneous ideas are assumed to underlie each of these concepts and arguments in their favour are not even entertained. The simile of a doctor's placebo is employed without any attempt at justification, simply because it suits Dawkins' view. It could equally well be asserted that the 'everlasting arms' are none the less real for being effective.

Dawkins' choice in developing these three particular 'memes' to illustrate the concept is indicative of an intrusive, overriding desire to discredit religion in general and Christianity in particular. But once again Dawkins has a double - edged sword in his hand when he tries to use the concept of 'memes' to debunk belief in God, belief in hell, and faith. For, according to 'meme - theory', disbelief in God, disbelief in hell, and unbelief are also memes which can be accounted for instrumentally, perhaps as desires to live precisely as one chooses and to escape any responsibility of a non - temporal kind! Dawkins' allied comparison of belief in God to a computer virus which goes on replicating itself is also a double - edged sword. For disbelief in God can equally well be compared to a computer virus.

Dawkins' attempts to make anti - religious capital in the treatment of a concept like a 'meme' is in keeping with the frequent asseverations which characterise other similar pronouncements, of which a few examples are given below:

Almost every species of bird is also perfectly capable of flying. Is it, then, another designed object? Actually, no! Birds may fly, but they were never designed. [CLSG, p. 10]

But there is no reason at all for us to expect any creatures to serve a useful purpose for us ... [CLSG, p. 19]

Originally there was no purpose in the universe. [CL 5]

If you ask people why they are convinced of the truth of their religion ... Nor do they appeal to evidence, There isn't any, and nowadays the better educated admit it. [SCAG]

Once again, such confidence would only be appropriate given some privileged insight into the way the world is.

Summarising the second part of this paper, Dawkins main arguments are variants based on an underlying misconception of the nature of explanation. The concept is not monolithic, but multifaceted. Scientific explanations are not the only types of explanation. Discussions about design, though changed from their Paleyean form, are not eliminated by evolution, but modified. Metaphorical language requires particular care in its use since it can confuse as well as clarify, not least on account of the power of persuasion vested in a carefully chosen metaphor and of its ability to turn round and bite the user.
Meaning and purpose

Dawkins' attempt to deal with the question of purpose in life is the most difficult in which to discern an intelligible argument. Consistent with his view that 'Religion is a scientific theory' [SCAG], he expects science, and science alone, to be able to answer ultimate questions:

> So where does life come from? What is it? Why are we here? What are we for? What is the meaning of life? There's a conventional wisdom which says that science has nothing to say about such questions. Well all I can say is that if science has nothing to say, it's certain that no other discipline can say anything at all. But in fact science has a great deal to say about such questions.[CL 1]

Dawkins then goes on to state what he believes to be the answers which science is able to give about purpose. A difficulty about these proffered answers is not so much what they affirm but what they deny. From his naturalistic stance, Dawkins fails to acknowledge the possibility of additional and compatible purposes to scientific ones. His position appears very poignantly in the following interchange:

> [after a little girl of six pointed out some flowers] I asked her what she thought flowers were for? She gave a very thoughtful answer. 'Two things', she said; 'to make the world pretty and to help the bees make honey for us.' Well, I thought that was a very nice answer and I was very sorry I had to tell her that it wasn't true. Her answer was not too different from the answer that most people throughout history would have given. The very first chapter of the Bible sets it out. Man has dominion over all living things. The animals and plants were there for our benefit. [CL4]

Dawkins overlooks the compatibility of such purposes as, 'to make the world pretty', to help the bees make honey and 'to help the bees make honey for us.' He answers his own question, 'What are flowers and bees. . . [and ourselves] really for? [CL 4]

> We are machines built by DNA whose purpose is to make more copies of the same DNA Flowers are for the same thing as everything else in the living kingdoms, for spreading 'copy - me' programmes about, written in DNA language.
>
> That is EXACTLY what we are for. We are machines for propagating DNA, and the propagation of DNA is a self sustaining process. It is every living objects' sole reason for living... [CLSG, p. 21]

The word 'sole' acts, of course, as just another opportunity implicitly to deny any religious reasons for living. Dawkins' dislike of teleology - of goal - directed properties - shows signs of strain at times when he finds it 'terribly, terribly tempting to use the word designed' and when he claim that 'The plants tolerate the bees eating some of their pollen because the provide such a valuable service, by carrying pollen from one flower to another.' [CLSG, p. 19] The thought of a plant not tolerating bees is an interesting one.

On the grand finale of the cosmic drama of which we are part, Dawkins concludes

> We can now see human purpose for what it really is. It is a product of our brains that has evolved by natural selection. Originally there was no purpose in the universe. For 3000 million years, life forms grew on this planet dripping with designoid elegance and reeking with apparent purpose. Then, came along one species that was given, natural selection, not digging claws like a mole or streamlining like dolphin, but a powerful and flexible on - board computer. This computer is our brain and the nature and potential of our brain is the difference between us and every other living thing. It is our sense of purpose. [CL5]

But, of course, a 'sense of purpose' is not the same as a 'purpose'. sense of purpose can be wholly illusory. In the first of the Christmas Lectures, Dawkins refers to

Faraday's reply to Sir Robert Peel's question, 'what is the use of science?'

'What is the use of a baby?' . . . it's also possible that what Faraday meant was there's no point in bringing a baby into the world if all that it's going to do is work to go on living to go on living and work to go living again. If that's all the point of life, what are we here for? There's got to be more to it than that [CL 1]

But if Dawkins' assertion that 'propagating DNA... is every living object's sole reason for living' [CLSG, p. 21], then all one is left with are the wistful echoes of his own words, 'There's got to be more to it than that.'
Referencing key to works by Richard Dawkins

IDSG - 'In Defence of Selfish Genes', Philosophy 56,556 - 573, 1981.

EP - The Extended Phenotype, Oxford: Oxford University Press, 1982.

BWM - The Blind Watchmaker, Harlow: Longman, 1986.

BWM TV - The Blind Watchmaker BBC 2 Horizon, 19 January 1987.

SG - The Selfish Gene, (2nd ed.), Oxford: Oxford University Press, 1989 (identical to lst ed. + Chs 12 & 13).

CL1 - lst 1991 Royal Institution Christmas Lecture - Waking up in the universe [series repeated in December 1992].

CL 2 - 2nd lecture - Designed and designoid objects.

CL 3 - 3rd lectur - Climbing Mount Improbable.

CL 4 - 4th lecture - The ultraviolet garden.

CL 5 - 5th lecture - The genesis of purpose.

CLSG - Christmas lecture study guide, Growing up in the universe, BBC Study Guide to the Christmas lectures, London: BBC Education 1991.

SCAG - 'A scientist's case against God' - an edited version of Dr Dawkins' speech at the Edinburgh International Science Festival on 15 April 1992, published in The Independent, 20 April 1992.

Richard Dawkins is a militant atheist. He is a zoologist and the first holder of the Charles Simonyi Professorship of Public Understanding of Science at Oxford. His works include The Selfish Gene, The Extended Phenotype, The Blind Watchmaker, River Out of Eden and Climbing Mount Improbable. He is also known for various broadcasts.

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Reply to Michael Poole
Professor Richard Dawkins

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The following comments are in response to an article by Michael Poole entitled 'A critique of aspects of the philosophy and theology of Richard Dawkins', Science and Christian Belief (1994) 69 41 - 59.

I am grateful to the Editor for inviting me to reply to Michael Poole's interesting article. Authors' replies to criticism predictably rely upon the 'I have been misquoted ... misunderstood ... misinterpreted - - .' formula. Poole's collation of my ideas is so thorough, and his representation of them so fair, that I have almost no complaints along these lines. On the contrary, when I see my own views so comprehensively expounded by so fairminded a critic, I find myself agreeing with them as strongly as ever!

I can fault his scholarship in only one detail, but it is a diverting one. He misattributes 'nothing - buttery' to the religious scientist Donald McKay in 1974. It is a mild irony that in fact the witticism was originally used against a theologian, Teilhard de Chardin, and as early as 1961. Sir Peter Medawar, the Nobel - prizewinning scientist and polymath, coined it in his brilliantly savage review (perhaps the most devastating book review ever written) of The Phenomenon of Man:

There is much else in the literary idiom of nature - philosophy: nothing buttery, for example, always part of the minor symptomatology of the bogus . . . 'the Christogenesis of St Paul and St John is nothing else and nothing less than the extension ... of that noogenesis in which cosmogenesis ... culminates.' It would have been a great disappointment to me if Vibration did not somewhere make itself felt, for all scientific mystics either vibrate in person or find themselves resonant with cosmic vibrations; but I am happy to say that on page 266 Teilhard will be found to do so.

Forgive me, I could not resist running the quotation on. As Medawar himself remarks, with Teilhard, to expound is to expose. Scientists will be incredulous that anyone could get such pretentious obscurantism published. New Age Travellers, of course, will love Teilhard for his vacuous imitation of profundity, but what about theologians - do they find Teilhard par for the course? Is this the kind of thing the Starbridge lecturer will be paid to teach? I hope that doesn't sound like a cheap jibe. It is not intended to be, but is there to make a serious point which is relevant to Poole's article. If the defence is made that Teilhard is bad theology and good theology is not like that, my reply would be this. By what standards are we to judge good theology from bad? We know how to judge bad science. Bad science is done from time to time and it is weeded out by publicly knowable procedures. But bad theology? How are we to detect that 'Love in all its subtleties is nothing more, and nothing less, than the more or less direct trace marked on the heart of the element by the Psychical convergence of the universe upon itself . . .' (Teilhard again) is different from good theology? What would good theology look like? Let's be charitable and assume that it would not look like the article that the Editors of this journal saw fit to publish immediately before Poole's in 'Science and Christian Belief:

'Ironically, the god of the process theologians is very abstract, and in that regard, very much the product of theoretical 'masculine' thought. One of the faults of process theology is that in order to accommodate contemporary scientific cosmology and academic language, it 'depersonifies' and 'dedivinizes' Christ. Ruether's struggle to find a culturally comfortable divinity by adding feminine identity to the generalities of the physics - oriented philosophers strikes an odd contrast to Gadon's goddess who, as a projection of artistic feminine psyche, is busy dancing through western culture in a flashy costume.'

This passage's reference to the struggle to find a culturally comfortable divinity is a good example of what may be called the 'Argument from Personal Comfort' and I'll return to Poole's usage of the Argument in his concluding remarks. Here, my purpose is to ask whether a piece of theological writing such as this, or the marginally more sensible quotations from Teilhard above, could ever be testable by any standards of evidence: standards that might be respected by scientists or by lawyers or by historians or by common sense? If so, well and good, but would it then be theology at all? Poole appears to be at best equivocal on the role of evidence in evaluating theological truth.

He is right that I pay religions the compliment of regarding them as scientific theories and that I see God as a competing explanation for facts about the universe and life. This is certainly how God has been seen by most theologians of past centuries and by most ordinary religious people today. But Poole is trying to have it both ways. On the one hand he is denying that religions provide explanations in the same sense as science, and trying to shield them from the critical rigours that scientific theories must endure. On the other hand, he tries to rescue the argument from design by suggesting, in the words of the elder Archbishop Temple, that evolution touches

... not the evidence of design but the mode in which the design was executed ... In the one case the Creator made the animals at once such as they now are; in the other case He impressed on certain particles of matter... such inherent powers that in the ordinary course of time living creatures such as the present were developed... He did not make the things, we may say; no, but He made them make themselves.

Now, if God set the Universe in motion and then sat back to watch evolution happen, a scientist should hope that there might be tracesevidence of His involvement in the shape of functioning of the universe. Some physicists, for example, have suggested that the fundamental constants of the universe are 'too good': that the laws of physics look as if they have been designed to make carbon chemistry and hence the evolution of life possible. Here we have an interesting argument and one which I should like to see spelled out and dissected thoroughly. But this will not happen if it is ruled out of bounds to critical argument. It must not be allowed to claim a kind of spurious diplomatic immunity by flashing its religious safeconduct at us.

If, on the other hand, there are no traces of God's involvement in the universe; if God did indeed set things up so that life would evolve, but covered His tracks so brilliantly that no clues remain; if He made the universe look exactly as it would be expected to look if He did not exist, then what we have is not an argument from design at all. There can be no argument from design if the universe is expertly designed to look undesigned. All we are left with, in this case, is the feeble, though strictly valid, argument that just because we can't find any evidence for a God, this doesn't prove that there isn't one. Of course we can't prove that there isn't a God.but, as has been said sufficiently often before, exactly the same can be said of fairies and Father Christmas.

Once again, this is not intended as cheap mockery but is making a point. If God really has a more solid basis than fairies, then let us hear it. If evidence is not forthcoming, then how can you answer a Fairy - worshipper who claims that his religion is as securely founded as yours? Not just a fairy - worshipper, note, for we could substitute an infinite variety of strictly undisprovable godlings and hobgodlings. Either admit that God is a scientific hypothesis and let him submit to the same judgement as any other scientific hypothesis. Or admit that his status is no higher than that of fairies and river sprites.

We now arrive at what, in various shapes and forms, amounts to the central disagreement that Poole has with me. He quotes me:

Any god worthy of the name must have been a being of colossal intelligence, a supermind, an entity of enormous sophistication and complexity. In other words, an entity of extremely low statistical probability - a very improbable being.

I must apologise for the repetitive style (this is not from a written source but is a verbatim transcript of a dialogue with the Archbishop of York) but I stand by the sentiment.

Parenthetically, Poole is confused about probability. He rightly says that probability is the ratio of the number of ways in which something happens to the number of ways in which something could happen. He wrongly goes on to say that this definition is not applicable to amazing, spooky coincidences because these are unique events. Yes, if a letter to a newspaper reports that the writer dreamed of an old friend and then woke up to discover that the friend had died in the night, this is, in a trivial sense, a unique event. But there is nothing to stop us estimating frequencies of relevant classes of events. How many readers of our newspapers are there; in other words what is the catchment area of the coincidence from the point of view of our hearing about it? How many of them dream and how often? How many friends do they typically have and what is the likelihood of one of their friends' dying per unit time? When this kind of calculation has been done, the conclusion is startling. There are likely to be hundreds of people experiencing coincidences at least as eerie as this one every day. You can't do the calculation as precisely as you can when cards or Coloured balls are involved. But everybody does an intuitive calculation of this kind in order to recognize a spooky coincidence in the first place. My point was that they usually are not trained to calculate it properly, and therefore conclude that the coincidence is more spooky than it is. The same kind of intuitive calculation lies behind the claim that the vertebrate eye is too improbable to have arisen by chance (in how many ways could the bits of an eye have been arranged, and how many of them would see?) and it lies behind my similar claim about God.

Poole, in his reply to that claim, appears to think that he has hoist me with my own petard:

Dawkins' constant assumption, echoing the popular demand, 'who made God?' is that since our common experience indicates that material objects have beginnings, God would also have had to have had an originator... His assumption is a particularly interesting one from the point of view of consistency of argument, since it is precisely this kind of analogical argument that he so vehemently rejects if applied to the world having a designer by comparison with everyday artefacts having designers.

There are three ways in which statistically improbable entities can come into being. First, luck. This is, for practical purposes, ruled out if the improbability is sufficiently high. Second, deliberate design which is, of course, how cars and buildings come into being. Third, evolution by gradual, cumulative degrees, guided by natural selection of random variation. This third theory is a genuine alternative to the designer theory, and Poole would not deny that it works for all the living things on this planet. Now, my argument with respect to God goes like this. We first note that a God capable of designing a universe (and incidentally capable of forgiving sins, impregnating virgins etc.) would have to be very sophisticated and complex. This rules out chance as an explanation, in exactly the same kind of way as chance is ruled out as an explanation for the eye. Right then, we are left with either a (meta) designer or gradual, cumulative evolution. I jumped straight to the familiar rhetorical question - 'But who designed God?' - because no theologian, to my knowledge, has ever proposed that God evolved to his awesome complexity by slow, gradual degrees (it would have to be a population of randomly varying Gods, by the way, if natural selection was the driving force). If any such suggestion were made, I should be intrigued and would give the hypothesis my best attention. But I am not optimistic that the hypothesis has much satisfaction to offer the religious. Evolution takes time and it needs a universe in which to operate. There is, therefore, to say the least, going to be a problem with any attempt to postulate an evolved God as the fons et origo of the universe. The theory that there might have been a natural selection among randomly varying universes is another matter and is very interesting, but I have no space to deal with it. It is not a religious theory.

The argument that an eye, say, or a backbone is too complicated to have arisen by chance is a good argument because 'arisen by chance' is a synonym for 'sprang spontaneously and instantaneously into existence.' The irony is that the argument against chance is conventionally used by creationists against evolution. In fact it is the most powerful argument against creation, because creation really does amount to something complicated springing spontaneously into existence. Evolution by natural selection offers the only ultimate solution so far suggested to the riddle of how complicated objects can exist, anywhere in the universe. Poole claims to accept the importance of Darwinism, but he fails to do justice to the colossal intellectual work that Darwinism is doing for us. Darwinism not only renders God unnecessary as an explanatory device. Most sophisticated theologians would admit this. God is also shown to be very very improbable indeed, for exactly the same reason as the spontaneous arising of the vertebrate eye is improbable. In the days before we understood how eyes could exist, God had a certain plausibility (illusory as Hume showed it to be). But by explaining eyes, and all other complex objects, Darwin has pulled the rug from under God's feet.

Poole's concluding remarks are puzzling. Unless I have misunderstood them, they amount to intellectual cowardice. 'But if Dawkins' assertion that "propagating DNA ... is every living object's sole reason for living", then all one is left with are the wistful echoes of his own words, "There's got to be more to it than that." ' Why has there got to be more to it than that? Not because of evidence or logic. No, the reason there has got to be more to it than that is simply that the universe would be a kinder and more comfortable place to live in if there were more to it than that! It is the Argument from Personal Comfort yet again. It amounts to saying: 'If X were so, the universe would be an intolerably bleak and meaningless place. Therefore X cannot be so.' More succinctly, it is equivalent to 'Nature abhors the Intolerable.' Would that it did.

Finally, it is not part of his main article but there is an innuendo in the Abstract which I cannot let pass. Poole fears that undue weight may be attached to scientists' views 'on matters outside of their own fields of expertise. This possibility seemed to be particularly acute during Richard Dawkins' 1991 Royal Institution Christmas Lectures, both on account of the number of anti - religious assertions and of the youth of the audience.'

'Matters outside their own fields of expertise' implies that the matters concerned are within somebody's field of expertise. When the matters concerned are the ultimate questions of existence and purpose, forgive me for hollow laughter at the pretensions of anybody to expertise in such a field. If the expertise suggested is 'theology' I am on record as doubting whether it is a subject at all. But the specific innuendo that I must counter lurks in the reference to the youth of the Christmas Lectures television audience. Though not spelled out, the implication rings out loud and clear that I abused a position of trust as an invited lecturer to young and vulnerable minds.

I'd have more sympathy with this accusation, were it not for the overwhelming preponderance of broadcast propaganda in the other direction. After my Christmas Lectures I received letters from the pious saying that they would have no objection if only I had qualified my remarks by saying: 'But I should warn you that many well - informed people think differently . . .' When did you last hear a priest - in the pulpit, on radio, on television, in infants' Sunday School - qualify his statement with 'But I should warn you that many well - informed people don't think God exists at all . . .'?

Richard Dawkins is a militant atheist. He is a zoologist and the first holder of the Charles Simonyi Professorship of Public Understanding of Science at Oxford. His works include The Selfish Gene, The Extended Phenotype, The Blind Watchmaker, River Out of Eden and Climbing Mount Improbable. He is also known for various broadcasts.

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Response to Richard Dawkins' Reply
Michael Poole

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The following comments are in response to a reply from Richard Dawkins about an article by Michael Poole entitled 'A critique of aspects of the philosophy and theology of Richard Dawkins', Science and Christian

Belief (1994) 69 41 - 59.

I am pleased that Richard Dawkins judges my critique of his views as fair. I shall endeavour to keep these additional remarks the same. However, I now wish to press home my points a little harder, for I see no way that my paper can encourage Dawkins to hold his views 'as strongly as ever', if he has taken the full force of the criticisms on board. I shall respond to his main points.
What constitutes a scientific theory?

Although Dawkins sees our 'central disagreement' as being over his idea of the probability of God, there is a more far - reaching point of disagreement. This concerns Dawkins' key thesis, his puzzling claim that 'religion is a scientific theory' which obliterates the philosophical distinction between science and metaphysics. Furthermore, he uses the phrase, 'not a religious theory', of one particular speculation about the origin of the universe. But, while using the terms 'scientific theory', 'religion' and religious theory', he offers no explication of, or demarcation criteria for, scientific or religious theories, which would enable us to evaluate his assertions.

There is a vast body of literature on the philosophy of science. On a realist view of science, scientific theories attempt to explain the physical properties of the world. Consequently a scientific journal is not dedicated to the publication of poetry, music, novels, art or history, because they are not considered to be science, even though each may take science as their subject material. The price of constructing a body of reliable scientific knowledge is a restriction on the types of questions which are addressed, although none of these other aspects of human experience are thereby discounted.

There is also an extensive philosophical literature concerned with identifying the universe of discourse of religion. One fairly standard approach is to say that the universe of discourse of religion is constituted by the concept of God, understood as 'transcendent conscious agency', coupled with explanations of those three terms. The approach is not entirely adequate since it does not embrace non - theistic religions; but it goes some way towards clarifying a dominant view.

The common demand, 'Prove to me scientifically that God exists', misunderstands both the nature of science and the nature of religion. Science is an inappropriate tool for adjudicating upon the existence of God. At the risk of over - simplifying, science is concerned with studying the natural world, the world of nature. Questions about God's existence are about whether there is anything other than nature to which nature owes its existence; and it is no use going to science, the study of nature, to determine whether there is anything other than nature.

Dawkins' alternatives, 'Either admit that God is a scientific hypothesis ... Or admit that his status is no higher than that of fairies and river sprites' both caricature a serious matter and coerce into an unnecessary either/or. It is perfectly possible both to reject the notion that 'God is a scientific hypothesis' and to reject the claim that God's 'status is no higher than that of fairies and river sprites'. I find it difficult to conceive how a serious or even a superficial reading of, say, the New Testament gospels could lead to equate their value with stories about fairies and river sprites!

If we are to find Dawkins' key thesis persuasive, he must spell out his criteria for judging theories as 'scientific'. If religion is admitted as a scientific theory, are aesthetics or history allowed in? If not, on what grounds are they excluded? We need to be provided with demarcation criteria for judging what are not scientific theories, criteria for differentiating between science and non - science. Furthermore, his statement that (natural selection among randomly varying universes ... is not a religious theory', presupposes he has demarcation criteria in mind for distinguishing between religious and non - religious theories. These, too, need explicating if we are to evaluate his key thesis.
The meaning of God as creator in Christian theology

God is not portrayed by Christian theology as a created being, something which Dawkins still has not taken on board. In responding to my observation that he appears to have moved by an analogical argument from immaterial objects have beginnings' to the assumption that God had a beginnings type of argument he has rightly eschewed about design Dawkins again asks 'who designed God?' He follows this with a lengthy passage on 'three ways in which statistically improbable entities can come into being.' But this passage does not contribute to the discussion, because it is predicated upon a 'when - did - you - stop - beating - your - wife' assumption about God. No one is pretending the idea that God is eternal is easy for time - dependent creatures like ourselves to grasp, any more than the allied one, presented by modern physics, that time itself comes into being with the universe. But it still has to be taken into account.

Dawkins also says, 'if God set the Universe in motion and then sat back to watch evolution happen, a scientist should hope that there might be traces evidence of His involvement in the shape or functioning of the universe.' Again, here are ideas which betray how deeply entrenched is Dawkins' misunderstanding of the orthodox Christian concept of God:

First, the idea of a God who creates and then sits back is not the God of biblical theism; it is the Cosmic Clockmaker of eighteenth century deism - the Retired Architect, the Absentee Landlord. Biblical theism presents a God who is immanent as well as transcendent, actively at work moment by moment in his world. That is one reason why it is ironic that evolutionary theory which, on one interpretation, reemphasised God's continuing activity after deism had lost sight of it, should be regarded as atheistic!

Second, there is the idea that the universe should contain 'traces - evidence of His involvement'. Dawkins questions whether the apparent 'fine - tuning' of the universe for life is one of those 'traces'. He also asks what it would be like 'if God did indeed set things up so that life would evolve, but covered His tracks so brilliantly that no clues remain; if He made the universe look exactly as it would be expected to look if He did not exist'. But Christian theology does not envisage the universe as being different from what it might have been if God did not exist, rather that there would be no universe. It is the whole universe that is the 'traces', not some little piece tacked on by way of a signature. To think otherwise bears certain similarities to searching the components of a jet engine for traces of Frank Whittle. The search is in vain; it is the whole engine which owes its being to Whittle's creativity, rather than any individual part bearing his signature. Furthermore, to expect the existence of God to be open to scientific tests is like trying to treat the existence of whittle as an engineering question!

Dawkins' statement, 'Darwinism ... renders God unnecessary as an explanatory device' makes me think I have not explained myself very well in my paper; for I have already given qualified agreement with this view. God is no more necessary in a scientific explanation of the world than Whittle is in a scientific explanation of the jet engine. But that does not justify denying the existence of God or Whittle! How could scientific explanations of the mechanisms of a creation conceivably offer any kind of competition to the existence of a creator? It would be nonsense, in a situation having a similar logical structure to regard the creator, Whittle, as a competing explanation to the mechanisms of the jet engine.

Creation, according to Dawkins in his reply, 'really does amount to something complicated springing spontaneously into existence'. In saying this I believe he is falling into the same mistake as some 'creationists', who think that to assert 'creation' necessitates holding the view that everything sprang into existence 'ready - made'. 'Creation', expresses God's relationship to the world, asserting that everything depends upon God for its existence. Creation, in its theological usage, is 'bringing - into - being - by - God' and is independent of any particular physical processes. To try to contrast the act of creation with the processes of, say, evolution by natural selection is to commit some kind of category mistake.
'Good theology' or 'bad theology'?

Dawkins' comments about Teilhard, whose views I am not concerned to defend, lead him to ask 'By what standards are we to judge good theology from bad?' Two criteria for judging good (Christian) theology are that it takes adequate account of (i) biblical material and (ii) extra - biblical material, such as evidence drawn from secular history. One of the criticisms I expressed in my paper concerned Dawkins' misinterpretation of what Christian theology says about God, miracles and faith. While no - one claims to be an expert on 'life, the universe and everything' the misconceptions to which I have referred are very basic ones about Christian theology, which even a cursory reading of the source documents could have avoided.

I am not clear why Dawkins says I appear 'to be at best equivocal on the role of evidence in evaluating theological truth.' I should have thought my quotation of Bruce made it abundantly clear that I count evidence as of fundamental importance, evidence which to use Dawkins' own words, 'might be respected by scientists or by lawyers or by historians'. His 'common sense' requirement is more contentious. It is the central thesis of a recent book by Prof. Lewis Wolpert that science has only developed in so far as it has departed from the dictates of common sense. Common sense is based on precedent and may therefore be an inadequate guide to something entirely novel, such as that central claim of Christianity, the resurrection of Jesus Christ.

In bad theology, people have cited selected parts of the 'Book of Nature' as if they were evidence for a creator's design, leaving the rest of the natural order in an implied state of 'non - created ambiguity'. This is rather like treating an author as the creator of one part of a book more than another. However, my comments on design were not, as Dawkins thinks, an attempt 'to rescue the argument from design'. His use of the definite article suggests that Paley's argument was the only form in which design could be envisaged, which it is not. I was simply concerned to spell out reasons for rejecting Dawkins' frequent assertions that chance plus selection rules out any idea of design in the universe and justifies coining a new 'deny - word', designoid. Furthermore, it is necessary to differentiate the scientific use of 'chance', which has no metaphysical overtones, from its popular use to assert the absence of purpose or plan. I am surprised that Dawkins, with his apparent antipathy towards metaphysics, should assign metaphysical meanings to the concept 'chance' as used in science.

To say, 'If God has a more solid basis than fairies, then let us hear it' conveys the impression that nobody has yet thought or written about Christian evidences! Dawkins has ready access to the whole theological collection of the University of Oxford if he wishes to avail himself of its resources. But evidence for God is not the same as watching intently at the bottom of the garden on a summer's night!

Grand theories, be they metaphysical ones like theism or atheism, or physical ones like stellar and organic evolution, can be judged against such criteria as

(i) comprehensiveness - taking into account all known data, deemed relevant;

(ii) consistency - freedom from internal contradictions;

(iii) coherence - holding together as a whole;

(iv) congruence - corresponding, coinciding with experience.

Probability

I suspect that part of our disagreement about probability arises over what constitutes a unique event. Dawkins considers someone dreaming that a friend has died, and finding they have, as a unique event. He then argues about the frequency of such dreams and the probability of deaths per unit time. But once there are other examples of such events, so that talk of frequencies becomes meaningful, the events cease to be unique. Indeed, the event, 'a person dreams that a friend dies when they do', is arguably unlikely to be unique in history. What is unique is that Sue Smith dreams that Bill Bloggs dies when he does.

Although I stand by my statement, 'There is no way of assigning mathematical probabilities to unique events', I agree with Dawkins that 'there is nothing to stop us estimating frequencies of relevant classes of events', even 'spooky events' reported in newspapers, provided there can be some kind of agreement about what constitutes the class of 'spooky events'. However, I was criticising Dawkins' use of the concept of probability in the precise calculus of coin - tossing to argue for the meaninglessness of what he calls 'uncanny, spooky, telepathic, experiences', which I assumed, and which he has not denied, would include claims about answered prayer. To say, 'when people write into the papers with uncanny experiences, it's just like that ... and it means absolutely nothing', is a non sequitur. Dawkins would have to have some privileged insight into the world in order to know that all reported uncanny experiences meant 'absolutely nothing'. Suppose for the sake of argument that there is a God who answers prayers and that these answers give rise to what Dawkins calls uncanny experiences. The occurrence of these experiences owes nothing whatever to the calculus of coin - tossing but occurs if and only if there is a God who answers prayer.

No 'Argument from Personal Comfort'

Dawkins' puzzlement over my closing remarks is quickly resolved. I am afraid he is right about misunderstanding them. I am not making any 'Argument from Personal Comfort'. I am simply quoting him. The words, 'There's got to be more to it than that', are Dawkins' words, not mine. I have watched the relevant section from the first Christmas lecture several times since reading Dawkins' reply, to check whether he was simply representing Faraday's views, which he had just commented on. But he speaks with great warmth about the idea that there has got to be more to life than just 'to work to go on living' and certainly does not introduce any notion that this might be seen as an 'Argument from Personal Comfort'. Any possible doubts as to whether Dawkins himself holds that 'There's got to be more to it [life] than that' are dispelled by his next words: 'Some of life must be devoted to living itself; some of life must be devoted to doing something worthwhile with one's life, not just to perpetuating it'! So my criticism of inconsistency remains, for this stands in complete contradiction to his other assertion that 'propagating DNA ... is every living object's sole reason for living'. If he stands by his latter claim, then as I concluded my article, Dawkins' own words, 'There's got to be more to it than that', have a wistful ring about them.

Education and Propaganda

Dawkins rightly discerned my innuendo in the Abstract about the impropriety of promoting an atheistic world - view in the name of science in his 1991 Christmas lectures. He has often gone on record as saying that the persistence of religion owes much to the gullibility of young people who will believe anything they are told in their early years. If young people are as easily taken in as he thinks, then the persistence of atheism could also owe much to the gullibility of young people.

My concern about these lectures was that they were intended to be educational ones about science, within which atheistic dogmatism was inappropriate. Dawkins disparagingly refers to 'the pious' who wrote afterwards to say that his remarks should have been qualified. But it was a valid objection. It is no defence for him to say that others have not qualified their remarks. That is only an argument for saying that they should have done so too! His example of 'priests' does not serve his cause, for belief in God is [generally!] an assumption of their position, which those who choose to listen to them take for granted.

Similarly, someone who chooses to go to a meeting of the British Humanist Association should not be surprised to hear criticisms of religion and would not expect to be reminded that some people do believe in God. But the school - children who went to the Christmas Lectures went to hear a series on science, which was used as a vehicle for promoting a personal world - view, that science pushed one into atheism. But this is not a necessary consequence of science and the view is one with which many scientists disagree. However, no indication was given that an opposite view could coherently and rationally be held - which amounts to propaganda.

Conclusion

In case it should appear otherwise from this critique, let me add that no personal animosity is intended or felt. I like Richard Dawkins' relaxed and clear lecturing style, enjoyed most of the Christmas lectures, and found the sequence about the baby to which I referred, delightfully sensitive. However, in my original paper and here, I have criticised the quality of many of the arguments which Dawkins has so vigorously sought to employ against Christianity 'in the name of science', through his books, lectures, newspaper articles, letters, and television appearances over many years.

One class of arguments starts from the assumptions of (i) God as a created being (ii) miracles as nothing other than 'more - or - less improbable natural events' and (iii) faith as unevidenced belief. But such assumptions form no part of traditional Christian theology. Consequently, arguments based on these assumptions do not actually engage with the intended target. They are directed against a 'straw' version of Christianity, one which the orthodox would not wish to defend.

A second class of arguments includes (i) meme theory (ii) the metaphor of religion as a 'mental virus' and (iii) the supposed readiness of the young to believe anything they are told. But these have no anti - Christian mileage in them whatsoever. They are simply theories about the ways in which ideas spread - any ideas. They have nothing to say about the truth or falsity of the beliefs themselves; they are equally applicable to the spread of atheism. To use them is to wield a two - edged sword which can wound the assailant as much as the intended victim.

Much of Dawkins' world - view depends on his central thesis that 'religion is a scientific theory', including his view of 'God as a competing explanation [to science] for facts about the universe and life'. I know of no professional philosopher who makes such a claim. But, conspicuous by its absence, is any attempt to justify such a contentious claim. However, the task has now become an urgent one for, unless Dawkins is able to mount a tightly argued justification of his central claim, much of his position remains poised precariously on insecure foundations.

Richard Dawkins is a militant atheist. He is a zoologist and the first holder of the Charles Simonyi Professorship of Public Understanding of Science at Oxford. His works include The Selfish Gene, The Extended Phenotype, The Blind Watchmaker, River Out of Eden and Climbing Mount Improbable. He is also known for various broadcasts.

Michael Poole is a committed Christian. He is a Visiting Research Fellow at King's College London where he was, for twenty years, a Lecturer in Science Education. His research interest is in the interplay between science and religion with special reference to the educational context. His books include Science and Belief, and Miracles: Science, Bible and Experience.

We are grateful to both authors for permission to make their debate available on the internet. It was originally published in the Christians in Science Journal: Science and Christian Belief in Vol 6 (April 1994) and Vol 7 (1995).

If you would like to put a question to CiS, please email the Secretary,
Dr Caroline Berry at secretary@cis.org.uk

To read more writings by Professor Richard Dawkins please see the
The World of Richard Dawkins, an unofficial web site.

Not in Our Genes, Biology, Ideology and Human Nature - Reviewed by Richard Dawkins
by Steven Rose, Leon J. Kamin and R.C.Lewontin (Pantheon Books, 1985)

Reviewed by Richard Dawkins in "Sociobiology: the debate continues", New Scientist 24 January 1985

Those of us with time to concentrate on our historic mission to exploit workers and oppress minorities have a great need to "legitimate" our nefarious activities. The first legitimator we came up with was religion which has worked pretty well through most of history but, "the static world of social relations legitimated by God reflected, and was reflected by, the dominant view of the natural world as itself static".

Latterly there has been an increasing need for a new legitimator. So we developed one: Science.

"The consequence was to change finally the form of the legitimating ideology of bourgeois society. No longer able to rely upon the myth of a deity. . . the dominant class dethroned God and replaced him with science. . . If anything, this new legitimator of the social order was more formidable than the one it replaced . . . Science is the ultimate legitimator of bourgeois ideology."

Legitimation is also the primary purpose of universities:

" . . . it is universities that have become the chief institutions for the creation of biological determinism . . . Thus, universities serve as creators, propagators, and legitimators of the ideology of biological determinism. If biological determinism is a weapon in the struggle between classes, then the universities are weapons factories, and their teaching and research faculties are the engineers, designers, and production workers."

And to think that, through all these years working in universities, I had imagined that the purpose of science was to solve the riddles of the Universe: to comprehend the nature of existence; of space and time and of eternity; of fundamental particles spread through 100 billion galaxies; of complexity and living organisation and the slow dance through three billion years of geological time. No no, these trivial matters fade into insignificance beside the overriding need to legitimate bourgeois ideology.

How can I sum up this book? Imagine a sort of scientific Dave Spart trying to get into "Pseud’s Corner’. Even the acknowledgements give us fair warning of what to expect. Where others might thank colleagues and friends, our authors acknowledge "lovers" and "comrades". Actually, I suppose there is something rather sweet about this, in a passé, sixtiesish sort of way. And the 1960s have a mythic role to play in the authors’ bizarre conspiracy theory of science. It was in response to that Arcadian decade (when "Students challenged the legitimacy of their universities . . . ") that "The newest form of biological determinism, sociobiology, has been legitimated . . . ".

Sociobiology, it seems, makes the two assertions "that are required if it is to serve as a legitimization and perpetuation of the social order" (my emphasis). The "Panglossianism"—J. B. S. Haldane’s term is (mis)used without acknowledgement—of sociobiology "has played an important role in legitimation", but this is not its main feature:

"Sociobiology is a reductionist, biological determinist explanation of human existence. Its adherents claim, first, that the details of present and past social arrangements are the inevitable manifestations of the specific action of genes."

Unfortunately, academic sociobiologists, unaccountably neglecting their responsibilities towards the class struggle, do not seem anywhere to have actually said that human social arrangements are the inevitable manifestations of genes. Rose et al have accordingly had to go farther afield for their substantiating quotations, getting them from such respected sociobiologists as Mr Patrick Jenkin when he was minister for social services, and various dubious representatives of the National Front and the Nouvelle Droite whose works most of us would not ordinarily see (they are no doubt grateful for the publicity). The minister gives especially good value, by using a "double legitimation of science and God . . ."

Enough of this, let me speak plainly. Rose et al cannot substantiate their allegation about sociobiologists believing in inevitable genetic determination, because the allegation is a simple lie. The myth of the "inevitability" of genetic effects has nothing whatever to do with sociobiology, and has everything to do with Rose et al’s paranoiac and demonological theology of science. Sociobiologists, such as myself (much as I have always disliked the name, this book finally provokes me to stand up and be counted), are in the business of trying to work out the conditions under which Darwinian theory might be applicable to behaviour. If we tried to do our Darwinian theorising without postulating genes affecting behaviour, we should get it wrong. That is why sociobiologists talk about genes so much, and that is all there is to it. The idea of "inevitability" never enters their heads.

Rose et al have no clear idea of what they mean by biological determinism. "Determinist", for them, is simply one half of a double-barrelled blunderbuss term, with much the same role and lack of content as "Mendelist-Morganist" had in the vocabulary of an earlier generation of comrades. Today's other barrel, fired off with equal monotony and imprecision is "reductionist".

"(Reductionists) argue that the properties of a human society are... no more than the sums of the individual behaviours and tendencies of the individual humans of which that society is composed. Societies are 'aggressive' because the individuals who compose them are 'aggressive', for instance.''

As I am described in the book as "the most reductionist of sociobiologists", I can speak with authority here. I believe that Bach was a musical man. Therefore of course, being a good reductionist, I must obviously believe that Bach's brain was made of musical atoms! Do Rose et al sincerely think that anybody could be that silly? Presumably not, yet my Bach -- example is a precise analogy to "Societies are 'aggressive' because the individuals who compose them are 'aggressive'".

Why do Rose et al find it necessary to reduce a perfectly sensible belief (that complex wholes should be explained in terms of their parts) to an idiotic travesty (that the properties of a complex whole are simply the sum of those same properties in the parts)? "In terms of" covers a multitude of highly sophisticated causal interactions, and mathematical relations of which summation is only the simplest. Reductionism, in the "sum of the parts" sense, is obviously daft, and is nowhere to be found in the writings of real biologists. Reductionism, in the "in terms of " sense, is, in the words of the Medawars, "the most successful research stratagem ever devised" (Aristotle to Zoos, 1984).

Rose et al tell us that " . . . some of the most penetrating and scathing critiques of sociobiology have come from anthropologists..." The two most famous anthropologists cited are Marshall Sahlins and Sherwood Washburn, and their "penetrating" critiques are, indeed, well worth looking up. Washburn thinks that, as all humans, regardless of kinship, share more than 99 per cent of their genes, " . . . genetics actually supports the beliefs of the social sciences, not the calculations of the sociobiologists." Lewontin, the brilliant geneticist, could, if he wanted to, quickly clear up this pathetic little misunderstanding of kin selection theory. Sahlins, in a book described as "a withering attack" on sociobiology, thinks that the theory of kin selection cannot work be cause only a minority of human cultures have developed the concept of the fraction (necessary, you see, in order for people to calculate their coefficients of relatedness!). Lewontin the geneticist would not tolerate elementary blunders like this from a first-year undergraduate. But for Lewontin the "radical scientist", apparently any criticism of sociobiology, no matter how bungling and ignorant, is penetrating, scathing, and withering.

Rose et al see their main role as a negative and purging one, even casting themselves as a gallant little fire brigade:

" . . . constantly being called out in the middle of the night to put out the latest conflagration . . . All of these deterministic (sic) fires need to be doused with the cold water of reason before the entire intellectual neighborhood is in flames."

This dooms them to constant nay-saying, and they therefore now feel an obligation to produce "some positive program for understanding human life". What, then, is our authors' positive contribution to understanding life?

At this point, self-conscious throat-clearing becomes almost audible and the reader is led to anticipate some good embarrassing stuff. We are promised "an alternative world view". What will it be? "Holistic biology"? "Structuralistic biology"? Connoisseurs of the genre might have put their money on either of these, or perhaps on "Deconstructionist biology". But the alternative world view turns out to be even better: "Dialectical" biology! And what exactly is dialectical biology? Well—think, for example:

"of the baking of a cake: the taste of the product is the result of a complex interaction of components—

such as butter, sugar, and flour—exposed for various periods to elevated temperatures; it is not dissociable into such-or-such a percent of flour, such-or-such of butter, etc., although each and every component. . . has its contribution to make to the final product."

When put like that, this dialectical biology seems to make a lot of sense. Perhaps even I can be a dialectical biologist. Come to think of it, isn't there something familiar about that cake? Yes, here it is, in a 1981 publication by the most reductionist of sociobiologists:

"... If we follow a particular recipe, word for word, in a cookery book, what finally emerges from the oven is a cake. we cannot now break the cake into its component crumbs and say: this crumb corresponds to the first word in the recipe; this crumb corresponds to the second word in the recipe, etc. With minor exceptions such as the cherry on top, there is no one-to-one mapping from words of recipe to 'bits' of cake. The whole recipe maps onto the whole cake."

I am not, of course, interested in claiming priority for the cake (Pat Bateson had it first, in any case). But what I do hope is that this little coincidence may at least give Rose and Lewontin pause. Could it be that their targets are not quite the naively atomistic reductionists they would desperately like them to be?

So, life is complex and its causal factors interact. If that is "dialectical", big deal. But no, it seems that "interactionism", though good in its way, is not quite "dialectical". And what is the difference?

" . . . First (interactionism) supposes the alienation of organism and the environment.... second, it accepts the ontological priority of the individual over the collectivity and therefore of the epistemological sufficiency of..." (emphasis mine).

There is no need to go on. This sort of writing appears to be intended to communicate nothing. Is it intended to impress, while putting down smoke to conceal the fact that nothing is actually being said?

The reader may have gained an impression of a silly, pretentious, obscurantist and mendacious book. To this should be added that the literary style of the book is well represented by my quotations. Yet Not in Our Genes has mysteriously attracted some favourable reviews, including one from a scientist whom I have always admired, and who clearly had no difficulty in rumbling its cant. I can only guess that such reviewers are decent liberal people who will simply bend over backwards to be nice to anyone attacking racialism and Cyril Burt.

Let me bend over backwards as far as I honestly can. To Leon Kamin belongs eternal credit for initiating the unmasking of Burt as a scientific criminal, and the chapters, presumably by Kamin, on IQ testing and similar topics, do partially redeem this otherwise fatuous book. Cyril Burt went to the extreme length of faking numerical data, but it can be argued that what lay behind his crime was an eagerness to give ideology priority over truth. If this is so, who are the Cyril Burts of today?

Article in The Guardian Tuesday April 10, 2001

Obituary for Michael Cullen, ethologist

Mike Cullen, who has died in a car crash in Australia aged 73, had an extraordinary influence on the development of ethology, the biological study of animal behaviour. He was of the generation of Oxford ethologists that included Robert Hinde, Aubrey Manning and Desmond Morris, and he was in many ways the unsung hero of that golden age in the subject. The impact of his razor-sharp, quantitative, analytical mind came not from his own research publications, which were modest in number, but from the difference he made to those who worked with him as doctoral students or colleagues.

Unusually, he was a scientist who put the development of others and of the subject as a whole ahead of his own career. All of us who worked with Mike can recall how he would take our half-baked ideas, inadequately analysed data, or the hesitant beginnings of a mathematical model, and transform them into a polished gem.

He would listen while eating his lunch from an old biscuit tin with a wire handle, one knee up, shoulders slightly hunched, rocking back and forth with absorption, hands fanned open and palms facing each other as if to grasp the issue under discussion. He would then rush off to a tutorial or lecture. But next day one would receive a handwritten letter with the solution to the problem, some lines of algebra, embellished by an apt - and untranslated - quotation from Catullus or a comic verse made up by Mike himself to suit the occasion.

Mike hardly ever accepted co-authorship of publications, but the acknowledgements sections of key papers published between the mid-1950s and 1980s show the breadth and depth of his influence, as do the career successes of his students. He was the kind of academic that would be pruned out in the contemporary, publish-or-perish, environment in universities. But if he had followed what is now the common practice of putting his name on all the papers of students and co-workers whom he had helped, he would have stood out as one of the most prolific ethologists of his time.

Mike was born in Bournemouth, but spent his first six years in India, where his father worked for the Bombay Company. Subsequently, together with his younger sister, he was brought up in England by a great aunt and educated at Marlborough College before going to Wadham College, Oxford, to read mathematics. He switched to zoology after the first year and graduated in 1952. His interest in natural history, and birds in particular, had been triggered in Kashmir in 1942.

A few years before Mike graduated, the Dutch ethologist Niko Tinbergen had moved to Oxford to set up the Animal Behaviour Group. Tinbergen is generally regarded, alongside Konrad Lorenz - with whom he shared a Nobel Prize in 1973 - as one of the founding fathers of ethology. Mike, with his interest in field biology, was naturally drawn to Tinbergen's group, and he completed his doctorate under Tinbergen on the behaviour of Arctic terns.

Tinbergen sent Mike and a Swiss student, Esther Sager, who worked on kittiwakes, together to the Farne Islands, off the coast of Northumberland. Perhaps unsurprisingly to their peers, Mike and Esther not only both came away with D Phil theses, but, in 1954, married and were to have two children. They stayed in Oxford, where Mike was Tinbergen's right-hand man from 1956 to 1969 in the Animal Behaviour Research Group, which was funded by Nature Conservancy.

Ethology at that time had been developing, under Tinbergen's influence, from largely observational studies of the behaviour of animals in their natural environment or in semi-natural captivity, into an experimental and quantitative discipline. Cullen's role in shaping this research agenda at Oxford was crucial: partly because of his mathematical facility - which Tinbergen almost totally lacked; but also because of his extraordinarily quick intelligence and his generosity in deploying it for the benefit of others

Almost all the students who came through the Tinbergen group from the mid-1950s to the early 70s found their intellectual inspiration in Mike. To collaborate with him was exhilarating. Everything happened at high speed, using rapidly improvised equipment which cost nothing. Typical of his ingenuity was his method of plotting the three-dimensional coordinates of fish swimming in schools: simply photograph them in a bright shadow-casting light, and do the necessary trigonometry using the distance between each fish and its shadow.

When Tinbergen retired in 1974 from the chair in animal behaviour, Cullen, who in 1968 had become lecturer in psychology - and a fellow of Wadham - was seen by many as his natural successor. However, although his huge influence was acknowledged, his modest output of published research weighed against him.

In 1977, Mike accepted an offer from Monash University in Melbourne, where he remained until he retired in 1993. While there, he dedicated much effort to preserving the penguins of Phillip Island, on which he also did much research: he considered his victory in this battle to be one of his greatest achievements.

Sadly, Mike and Esther separated after their move to Australia, but Mike later found happiness with Rita Krishovski. Mike was a warm-hearted, humorous and extraordinarily generous colleague, with an insatiable appetite and youthful enthusiasm for research. He was also a brilliant lecturer, and a model of what an Oxford tutor should be. Though a very private person, he would provide a sympathetic shoulder and a strong arm when a student or colleague came to him with private difficulties.

Stories of his mild eccentricities abound: his party act of fire-eating; his habit of knitting in seminars to avoid wasting time with his hands; and taking binoculars to conferences, to scrutinise details of tables and graphs shown by speakers.

Partly as a result of his casual dress and athletic appearance, he always looked much younger than he was. In seminars he was a formidable sceptic and questioner: if you could get your research past those quizzical eyebrows, you had nothing to fear from any audience in the world. We have lost a much- loved mentor who taught us how teaching should be.

• Michael Cullen, ethologist, born December 14 1927; died March 23 2001

ONE SIDE CAN BE WRONG [9.1.05]
by Richard Dawkins & Jerry Coyne

RICHARD DAWKINS is Charles Simonyi professor of the public understanding of science at Oxford University. His latest book is The Ancestor's Tale: A Pilgrimage to the Dawn of Life.

JERRY COYNE is a professor in the department of ecology and evolution at the University of Chicago, and the author (with H. Allen Orr) of Speciation.

Richard Dawkins's Edge Bio Page

Jerry Coyne's Edge Bio Page

ONE SIDE CAN BE WRONG

The seductive "let's teach the controversy" language still conveys the false, and highly pernicious, idea that there really are two sides. This would distract students from the genuinely important and interesting controversies that enliven evolutionary discourse. Worse, it would hand creationism the only victory it realistically aspires to. Without needing to make a single good point in any argument, it would have won the right for a form of supernaturalism to be recognised as an authentic part of science. And that would be the end of science education in America.

xxxx

(RICHARD DAWKINS & JERRY COYNE:) It sounds so reasonable, doesn't it? Such a modest proposal. Why not teach "both sides" and let the children decide for themselves? As President Bush said, "You're asking me whether or not people ought to be exposed to different ideas, the answer is yes." At first hearing, everything about the phrase "both sides" warms the hearts of educators like ourselves.

One of us spent years as an Oxford tutor and it was his habit to choose controversial topics for the students' weekly essays. They were required to go to the library, read about both sides of an argument, give a fair account of both, and then come to a balanced judgment in their essay. The call for balance, by the way, was always tempered by the maxim, "When two opposite points of view are expressed with equal intensity, the truth does not necessarily lie exactly half way between. It is possible for one side simply to be wrong."

As teachers, both of us have found that asking our students to analyse controversies is of enormous value to their education. What is wrong, then, with teaching both sides of the alleged controversy between evolution and creationism or "intelligent design" (ID)? And, by the way, don't be fooled by the disingenuous euphemism. There is nothing new about ID. It is simply creationism camouflaged with a new name to slip (with some success, thanks to loads of tax-free money and slick public-relations professionals) under the radar of the US Constitution's mandate for separation between church and state.

Why, then, would two lifelong educators and passionate advocates of the "both sides" style of teaching join with essentially all biologists in making an exception of the alleged controversy between creation and evolution? What is wrong with the apparently sweet reasonableness of "it is only fair to teach both sides"? The answer is simple. This is not a scientific controversy at all. And it is a time-wasting distraction because evolutionary science, perhaps more than any other major science, is bountifully endowed with genuine controversy.

Among the controversies that students of evolution commonly face, these are genuinely challenging and of great educational value: neutralism versus selectionism in molecular evolution; adaptationism; group selection; punctuated equilibrium; cladism; "evo-devo"; the "Cambrian Explosion"; mass extinctions; interspecies competition; sympatric speciation; sexual selection; the evolution of sex itself; evolutionary psychology; Darwinian medicine and so on. The point is that all these controversies, and many more, provide fodder for fascinating and lively argument, not just in essays but for student discussions late at night.

Intelligent design is not an argument of the same character as these controversies. It is not a scientific argument at all, but a religious one. It might be worth discussing in a class on the history of ideas, in a philosophy class on popular logical fallacies, or in a comparative religion class on origin myths from around the world. But it no more belongs in a biology class than alchemy belongs in a chemistry class, phlogiston in a physics class or the stork theory in a sex education class. In those cases, the demand for equal time for "both theories" would be ludicrous. Similarly, in a class on 20th-century European history, who would demand equal time for the theory that the Holocaust never happened?

So, why are we so sure that intelligent design is not a real scientific theory, worthy of "both sides" treatment? Isn't that just our personal opinion? It is an opinion shared by the vast majority of professional biologists, but of course science does not proceed by majority vote among scientists. Why isn't creationism (or its incarnation as intelligent design) just another scientific controversy, as worthy of scientific debate as the dozen essay topics we listed above? Here's why.

If ID really were a scientific theory, positive evidence for it, gathered through research, would fill peer-reviewed scientific journals. This doesn't happen. It isn't that editors refuse to publish ID research. There simply isn't any ID research to publish. Its advocates bypass normal scientific due process by appealing directly to the non-scientific public and - with great shrewdness - to the government officials they elect.

The argument the ID advocates put, such as it is, is always of the same character. Never do they offer positive evidence in favour of intelligent design. All we ever get is a list of alleged deficiencies in evolution. We are told of "gaps" in the fossil record. Or organs are stated, by fiat and without supporting evidence, to be "irreducibly complex": too complex to have evolved by natural selection.

In all cases there is a hidden (actually they scarcely even bother to hide it) "default" assumption that if Theory A has some difficulty in explaining Phenomenon X, we must automatically prefer Theory B without even asking whether Theory B (creationism in this case) is any better at explaining it. Note how unbalanced this is, and how it gives the lie to the apparent reasonableness of "let's teach both sides". One side is required to produce evidence, every step of the way. The other side is never required to produce one iota of evidence, but is deemed to have won automatically, the moment the first side encounters a difficulty - the sort of difficulty that all sciences encounter every day, and go to work to solve, with relish.

What, after all, is a gap in the fossil record? It is simply the absence of a fossil which would otherwise have documented a particular evolutionary transition. The gap means that we lack a complete cinematic record of every step in the evolutionary process. But how incredibly presumptuous to demand a complete record, given that only a minuscule proportion of deaths result in a fossil anyway.

The equivalent evidential demand of creationism would be a complete cinematic record of God's behaviour on the day that he went to work on, say, the mammalian ear bones or the bacterial flagellum - the small, hair-like organ that propels mobile bacteria. Not even the most ardent advocate of intelligent design claims that any such divine videotape will ever become available.

Biologists, on the other hand, can confidently claim the equivalent "cinematic" sequence of fossils for a very large number of evolutionary transitions. Not all, but very many, including our own descent from the bipedal ape Australopithecus. And - far more telling - not a single authentic fossil has ever been found in the "wrong" place in the evolutionary sequence. Such an anachronistic fossil, if one were ever unearthed, would blow evolution out of the water.

As the great biologist J B S Haldane growled, when asked what might disprove evolution: "Fossil rabbits in the pre-Cambrian." Evolution, like all good theories, makes itself vulnerable to disproof. Needless to say, it has always come through with flying colours.

Similarly, the claim that something - say the bacterial flagellum - is too complex to have evolved by natural selection is alleged, by a lamentably common but false syllogism, to support the "rival" intelligent design theory by default. This kind of default reasoning leaves completely open the possibility that, if the bacterial flagellum is too complex to have evolved, it might also be too complex to have been created. And indeed, a moment's thought shows that any God capable of creating a bacterial flagellum (to say nothing of a universe) would have to be a far more complex, and therefore statistically improbable, entity than the bacterial flagellum (or universe) itself - even more in need of an explanation than the object he is alleged to have created.

If complex organisms demand an explanation, so does a complex designer. And it's no solution to raise the theologian's plea that God (or the Intelligent Designer) is simply immune to the normal demands of scientific explanation. To do so would be to shoot yourself in the foot. You cannot have it both ways. Either ID belongs in the science classroom, in which case it must submit to the discipline required of a scientific hypothesis. Or it does not, in which case get it out of the science classroom and send it back into the church, where it belongs.

In fact, the bacterial flagellum is certainly not too complex to have evolved, nor is any other living structure that has ever been carefully studied. Biologists have located plausible series of intermediates, using ingredients to be found elsewhere in living systems. But even if some particular case were found for which biologists could offer no ready explanation, the important point is that the "default" logic of the creationists remains thoroughly rotten.

There is no evidence in favour of intelligent design: only alleged gaps in the completeness of the evolutionary account, coupled with the "default" fallacy we have identified. And, while it is inevitably true that there are incompletenesses in evolutionary science, the positive evidence for the fact of evolution is truly massive, made up of hundreds of thousands of mutually corroborating observations. These come from areas such as geology, paleontology, comparative anatomy, physiology, biochemistry, ethology, biogeography, embryology and - increasingly nowadays - molecular genetics.

The weight of the evidence has become so heavy that opposition to the fact of evolution is laughable to all who are acquainted with even a fraction of the published data. Evolution is a fact: as much a fact as plate tectonics or the heliocentric solar system.

Why, finally, does it matter whether these issues are discussed in science classes? There is a case for saying that it doesn't - that biologists shouldn't get so hot under the collar. Perhaps we should just accept the popular demand that we teach ID as well as evolution in science classes. It would, after all, take only about 10 minutes to exhaust the case for ID, then we could get back to teaching real science and genuine controversy.

Tempting as this is, a serious worry remains. The seductive "let's teach the controversy" language still conveys the false, and highly pernicious, idea that there really are two sides. This would distract students from the genuinely important and interesting controversies that enliven evolutionary discourse. Worse, it would hand creationism the only victory it realistically aspires to. Without needing to make a single good point in any argument, it would have won the right for a form of supernaturalism to be recognised as an authentic part of science. And that would be the end of science education in America.

Arguments worth having ...

The "Cambrian Explosion"

Although the fossil record shows that the first multicellular animals lived about 640m years ago, the diversity of species was low until about 530m years ago. At that time there was a sudden explosion of many diverse marine species, including the first appearance of molluscs, arthropods, echinoderms and vertebrates. "Sudden" here is used in the geological sense; the "explosion" occurred over a period of 10m to 30m years, which is, after all, comparable to the time taken to evolve most of the great radiations of mammals. This rapid diversification raises fascinating questions; explanations include the evolution of organisms with hard parts (which aid fossilisation), the evolutionary "discovery" of eyes, and the development of new genes that allowed parts of organisms to evolve independently.

The evolutionary basis of human behaviour

The field of evolutionary psychology (once called "sociobiology") maintains that many universal traits of human behaviour (especially sexual behaviour), as well as differences between individuals and between ethnic groups, have a genetic basis. These traits and differences are said to have evolved in our ancestors via natural selection. There is much controversy about these claims, largely because it is hard to reconstruct the evolutionary forces that acted on our ancestors, and it is unethical to do genetic experiments on modern humans.

Sexual versus natural selection

Although evolutionists agree that adaptations invariably result from natural selection, there are many traits, such as the elaborate plumage of male birds and size differences between the sexes in many species, that are better explained by "sexual selection": selection based on members of one sex (usually females) preferring to mate with members of the other sex that show certain desirable traits. Evolutionists debate how many features of animals have resulted from sexual as opposed to natural selection; some, like Darwin himself, feel that many physical features differentiating human "races" resulted from sexual selection.

The target of natural selection

Evolutionists agree that natural selection usually acts on genes in organisms - individuals carrying genes that give them a reproductive or survival advantage over others will leave more descendants, gradually changing the genetic composition of a species. This is called "individual selection". But some evolutionists have proposed that selection can act at higher levels as well: on populations (group selection), or even on species themselves (species selection). The relative importance of individual versus these higher order forms of selection is a topic of lively debate.

Natural selection versus genetic drift

Natural selection is a process that leads to the replacement of one gene by another in a predictable way. But there is also a "random" evolutionary process called genetic drift, which is the genetic equivalent of coin-tossing. Genetic drift leads to unpredictable changes in the frequencies of genes that don't make much difference to the adaptation of their carriers, and can cause evolution by changing the genetic composition of populations. Many features of DNA are said to have evolved by genetic drift. Evolutionary geneticists disagree about the importance of selection versus drift in explaining features of organisms and their DNA. All evolutionists agree that genetic drift can't explain adaptive evolution. But not all evolution is adaptive.

[Editor's Note: First published in The Guardian, on Thursday, September 1st]

Postmodernism Disrobed

Richard Dawkins' review of *Intellectual Impostures* by Alan Sokal and Jean Bricmont. Profile Books 1998, £9.99. To be published in U.S.A. by Picador as *Fashionable Nonsense.*

Published as 'Postmodernism Disrobed', *Nature* 394, pp 141-143, 9th July 1998

Suppose you are an intellectual impostor with nothing to say, but with strong ambitions to succeed in academic life, collect a coterie of reverent disciples and have students around the world anoint your pages with respectful yellow highlighter. What kind of literary style would you cultivate? Not a lucid one, surely, for clarity would expose your lack of content. The chances are that you would produce something like the following:

> We can clearly see that there is no bi-univocal correspondence between linear signifying links or archi-writing, depending on the author, and this multireferential, multi-dimensional machinic catalysis. The symmetry of scale, the transversality, the pathic non-discursive character of their expansion: all these dimensions remove us from the logic of the excluded middle and reinforce us in our dismissal of the ontological binarism we criticised previously.

This is a quotation from the psychoanalyst FŽlix Guattari, one of many fashionable French 'intellectuals' outed by Alan Sokal and Jean Bricmont in their splendid book *Intellectual Impostures,* which caused a sensation when published in French last year, and which is now released in a completely rewritten and revised English edition. Guattari goes on indefinitely in this vein and offers, in the opinion of Sokal and Bricmont, "the most brilliant mŽlange of scientific, pseudo-scientific and philosophical jargon that we have ever encountered." Guattari's close collaborator, the late Gilles Deleuze had a similar talent for writing:-

> In the first place, singularities-events correspond to heterogeneous series which are organized into a system which is neither stable nor unstable, but rather 'metastable,' endowed with a potential energy wherein the differences between series are distributed . . . In the second place, singularities possess a process of auto-unification, always mobile and displaced to the extent that a paradoxical element traverses the series and makes them resonate, enveloping the corresponding singular points in a single aleatory point and all the emissions, all dice throws, in a single cast.

It calls to mind Peter Medawar's earlier characterisation of a certain type of French intellectual style (note, in passing the contrast offered by Medawar's own elegant and clear prose):

> Style has become an object of first importance, and what a style it is! For me it has a prancing, high-stepping quality, full of self-importance; elevated indeed, but in the balletic manner, and stopping from time to time in studied attitudes, as if awaiting an outburst of applause. It has had a deplorable influence on the quality of modern thought . . .

Returning to attack the same targets from another angle, Medawar says:

> I could quote evidence of the beginnings of a whispering campaign against the virtues of clarity. A writer on structuralism in the *Times Literary Supplement* has suggested that thoughts which are confused and tortuous by reason of their profundity are most appropriately expressed in prose that is deliberately unclear. What a preposterously silly idea! I am reminded of an air-raid warden in wartime Oxford who, when bright moonlight seemed to be defeating the spirit of the blackout, exhorted us to wear dark glasses. He, however, was being funny on purpose.

This is from Medawar 1968 Lecture on "Science and Literature", reprinted in *Pluto's Republic* (Oxford University Press, 1982). Since Medawar's time, the whispering campaign has raised its voice.

Deleuze and Guattari have written and collaborated on books described by the celebrated Michel Foucault as "among the greatest of the great. . . Some day, perhaps, the century will be Deleuzian." Sokal and Bricmont, however, comment that "These texts contain a handful of intelligible sentences – sometimes banal, sometimes erroneous – and we have commented on some of them in the footnotes. For the rest, we leave it to the reader to judge."

But it's tough on the reader. No doubt there exist thoughts so profound that most of us will not understand the language in which they are expressed. And no doubt there is also language designed to be unintelligible in order to conceal an absence of honest thought. But how are we to tell the difference? What if it really takes an expert eye to detect whether the emperor has clothes? In particular, how shall we know whether the modish French 'philosophy', whose disciples and exponents have all but taken over large sections of American academic life, is genuinely profound or the vacuous rhetoric of mountebanks and charlatans?

Sokal and Bricmont are professors of physics at, respectively New York University and the University of Louvain. They have limited their critique to those books that have ventured to invoke concepts from physics and mathematics. Here they know what they are talking about, and their verdict is unequivocal: on Lacan, for example, whose name is revered by many in humanities departments throughout American and British universities, no doubt partly because he simulates a profound understanding of mathematics:

> . . . although Lacan uses quite a few key words from the mathematical theory of compactness, he mixes them up arbitrarily and without the slightest regard for their meaning. His ‘definition’ of compactness is not just false: it is gibberish.

They go on to quote the following remarkable piece of reasoning by Lacan:

> Thus, by calculating that signification according to the algebraic method used here, namely:
>
> $$\frac{S\ (\text{signifier})}{s\ (\text{signified})} = s\ (\text{the statement}),$$
>
> With S = (-1), produces: s = sqrt(-1)

You don’t have to be a mathematician to see that this is ridiculous. It recalls the Aldous Huxley character who proved the existence of God by dividing zero into a number, thereby deriving the infinite. In a further piece of reasoning which is entirely typical of the *genre*, Lacan goes on to conclude that the erectile organ

> . . . is equivalent to the sqrt(-1) of the signification produced above, of the *jouissance* that it restores by the coefficient of its statement to the function of lack of signifier (-1).

We do not need the mathematical expertise of Sokal and Bricmont to assure us that the author of this stuff is a fake. Perhaps he is genuine when he speaks of non-scientific subjects? But a philosopher who is caught equating the erectile organ to the square root of minus one has, for my money, blown his credentials when it comes to things that I *don’t* know anything about.

The feminist ‘philosopher’ Luce Irigaray is another who is given whole chapter treatment by Sokal and Bricmont. In a passage reminiscent of a notorious feminist description of Newton’s *Principia* (a ‘rape manual’) Irigaray argues that $E=mc^2$ is a ‘sexed equation’. Why? Because ‘it *privileges* the speed of light over other speeds that are vitally necessary to us’ (my emphasis of what I am rapidly coming to learn is an in-word). Just as typical of the school of thought under examination is Irigaray’s thesis on fluid mechanics. Fluids, you see, have been unfairly neglected. ‘Masculine physics’ *privileges* rigid, solid things. Her American expositor Katherine Hayles made the mistake of re-expressing Irigaray’s thoughts in (comparatively) clear language. For once, we get a reasonably unobstructed look at the emperor and, yes, he has no clothes:

> The privileging of solid over fluid mechanics, and indeed the inability of science to deal with turbulent

> flow at all, she attributes to the association of fluidity with femininity. Whereas men have sex organs that protrude and become rigid, women have openings that leak menstrual blood and vaginal fluids. . . From this perspective it is no wonder that science has not been able to arrive at a successful model for turbulence. The problem of turbulent flow cannot be solved because the conceptions of fluids (and of women) have been formulated so as necessarily to leave unarticulated remainders.

You don’t have to be a physicist to smell out the daffy absurdity of this kind of argument (the tone of it has become all too familiar), but it helps to have Sokal and Bricmont on hand to tell us the real reason why turbulent flow is a hard problem (the Navier-Stokes equations are difficult to solve).

In similar manner, Sokal and Bricmont expose Bruno Latour’s confusion of relativity with relativism, Lyotard’s ‘postmodern science’, and the widespread and predictable misuses of Gšdel’s Theorem, quantum theory and chaos theory. The renowned Jean Baudrillard is only one of many to find chaos theory a useful tool for bamboozling readers. Once again, Sokal and Bricmont help us by analysing the tricks being played. The following sentence, "though constructed from scientific terminology, is meaningless from a scientific point of view":

> Perhaps history itself has to be regarded as a chaotic formation, in which acceleration puts an end to linearity and the turbulence created by acceleration deflects history definitively from its end, just as such turbulence distances effects from their causes.

I won’t quote any more, for, as Sokal and Bricmont say, Baudrillard’s text "continues in a gradual crescendo of nonsense." They again call attention to "the high density of scientific and pseudo-scientific terminology – inserted in sentences that are, as far as we can make out, devoid of meaning." Their summing up of Baudrillard could stand for any of the authors criticised here, and lionised throughout America:

> In summary, one finds in Baudrillard’s works a profusion of scientific terms, used with total disregard for their meaning and, above all, in a context where they are manifestly irrelevant. Whether or not one interprets them as metaphors, it is hard to see what role they could play, except to give an appearance of profundity to trite observations about sociology or history. Moreover, the scientific terminology is mixed up with a non-scientific vocabulary that is employed with equal sloppiness. When all is said and done, one wonders what would be left of Baudrillard’s thought if the verbal veneer covering it were stripped away.

But don't the postmodernists claim only to be 'playing games'? Isn't it the whole point of their philosophy that anything goes, there is no absolute truth, anything written has the same status as anything else, no point of view is privileged? Given their own standards of relative truth, isn't it rather unfair to take them to task for fooling around with word-games, and playing little jokes on readers? Perhaps, but one is then left wondering why their writings are so stupefyingly boring. Shouldn't games at least be entertaining, not po-faced, solemn and pretentious? More tellingly, if they are only joking around, why do they react with such shrieks of dismay when somebody plays a joke at their expense. The genesis of *Intellectual Impostures* was a brilliant hoax perpetrated by Alan Sokal, and the stunning success of his *coup* was not greeted with the chuckles of delight that one might have hoped for after such a feat of deconstructive game playing. Apparently, when you've become the establishment, it ceases to be funny when somebody punctures the established bag of wind.

As is now rather well known, in 1996 Sokal submitted to the American journal *Social Text* a paper called 'Transgressing the Boundaries: towards a transformative hermeneutics of quantum gravity.' From start to finish the paper was nonsense. It was a carefully crafted parody of postmodern metatwaddle. Sokal was inspired to do this by Paul Gross and Normal Levitt's *Higher Superstition: the academic left and its quarrels with science* (Johns Hopkins, 1994), an important book which deserves to become as well known in Britain as it already is in America. Hardly able to believe what he read in this book, Sokal followed up the references to postmodern literature, and found that Gross and Levitt did not exaggerate. He resolved to do something about it. In Gary Kamiya's words:

> Anyone who has spent much time wading through the pious, obscurantist, jargon-filled cant that now passes for 'advanced' thought in the humanities knew it was bound to happen sooner or later: some clever academic, armed with the not-so-secret passwords ('hermeneutics,' 'transgressive,' 'Lacanian,' 'hegemony,' to name but a few) would write a completely bogus paper, submit it to an *au courant* journal, and have it accepted . . . Sokal's piece uses all the right terms. It cites all the best people. It whacks sinners (white men, the 'real world'), applauds the virtuous (women, general metaphysical lunacy) . . . And it is complete, unadulterated bullshit – a fact that somehow escaped the attention of the high-powered editors of *Social Text*, who must now be experiencing that queasy sensation that afflicted the Trojans the morning after they pulled that nice big gift horse into their city.

Sokal's paper must have seemed a gift to the editors because this was a *physicist* saying all the right-on things they wanted to hear, attacking the 'post-Enlightenment hegemony' and such uncool notions as the existence of the real world. They didn't know that Sokal had also crammed his paper with egregious scientific howlers, of a kind that any referee with an undergraduate degree in physics would instantly have detected. It was sent to no such referee. The editors, Andrew Ross and others, were satisfied that its ideology conformed to their own, and were perhaps flattered by references to their own works. This ignominious piece of editing rightly earned them the 1996 Ig Nobel Prize for literature.

Notwithstanding the egg all over their faces, and despite their feminist pretensions, these editors are dominant males in the academic lekking arena. Andrew Ross himself has the boorish, tenured confidence to say things like "I am glad to be rid of English Departments. I hate literature, for one thing, and English departments tend to be full of people who love literature"; and the yahooish complacency to begin a book on ‘science studies’ with these words: "This book is dedicated to all of the science teachers I never had. It could only have been written without them." He and his fellow ‘cultural studies’ and ‘science studies’ barons are not harmless eccentrics at third rate state colleges. Many of them have tenured professorships at some of America’s best universities. Men of this kind sit on appointment committees, wielding power over young academics who might secretly aspire to an *honest* academic career in literary studies or, say, anthropology. I know – because many of them have told me – that there are sincere scholars out there who would speak out if they dared, but who are intimidated into silence. To them, Alan Sokal will appear as a hero, and nobody with a sense of humour or a sense of justice will disagree. It helps, by the way, although it is strictly irrelevant, that his own left wing credentials are impeccable.

In a detailed post-mortem of his famous hoax, submitted to *Social Text* but predictably rejected by them and published elsewhere, Sokal notes that, in addition to numerous half truths, falsehoods and non-sequiturs, his original article contained some "syntactically correct sentences that have no meaning whatsoever." He regrets that there were not more of the latter: "I tried hard to produce them, but I found that, save for rare bursts of inspiration, I just didn’t have the knack." If he were writing his parody today, he’d surely have been helped by a virtuoso piece of computer programming by Andrew Bulhak of Melbourne: the *Postmodernism Generator*. Every time you visit it, at http://www.elsewhere.org/cgi-bin/postmodern , it will spontaneously generate for you, using falutless grammatical principles, a spanking new postmodern discourse, never before seen. I have just been there, and it produced for me a 6,000 word article called "Capitalist theory and the subtextual paradigm of context" by "David I.L.Werther and Rudolf du Garbandier of the Department of English, Cambridge University" (poetic justice there, for it was Cambridge who saw fit to give Jacques Derrida an honorary degree). Here’s a typical sentence from this impressively erudite work:

> If one examines capitalist theory, one is faced with a choice: either reject neotextual materialism or conclude that society has objective value. If dialectic desituationism holds, we have to choose between Habermasian discourse and the subtextual paradigm of context. It could be said that the subject is contextualised into a textual nationalism that includes truth as a reality. In a sense, the premise of the subtextual paradigm of context states that reality comes from the collective unconscious.

Visit the Postmodernism Generator. It is a literally infinite source of randomly generated syntactically correct nonsense, distinguishable from the real thing only in being more fun to read. You could generate thousands of papers per day, each one unique and ready for publication, complete with numbered endnotes. Manuscripts should be submitted to the ‘Editorial Collective’ of *Social Text,* double-spaced and in triplicate.

As for the harder task of reclaiming humanities and social studies departments for genuine scholars, Sokal and Bricmont have joined Gross and Levitt in giving a friendly and sympathetic lead from the world of science. We must hope that it will be followed.

John Catalano

Religion's Misguided Missiles
Article in The Guardian
Published Saturday September 15, 2001

Richard Dawkins

A guided missile corrects its trajectory as it flies, homing in, say, on the heat of a jet plane's exhaust. A great improvement on a simple ballistic shell, it still cannot discriminate particular targets. It could not zero in on a designated New York skyscraper if launched from as far away as Boston

That is precisely what a modern "smart missile" can do. Computer miniaturisation has advanced to the point where one of today's smart missiles could be programmed with an image of the Manhattan skyline together with instructions to home in on the north tower of the World Trade Centre. Smart missiles of this sophistication are possessed by the United States, as we learned in the Gulf war, but they are economically beyond ordinary terrorists and scientifically beyond theocratic governments. Might there be a cheaper and easier alternative?

In the second world war, before electronics became cheap and miniature, the psychologist BF Skinner did some research on pigeon-guided missiles. The pigeon was to sit in a tiny cockpit, having previously been trained to peck keys in such a way as to keep a designated target in the centre of a screen. In the missile, the target would be for real.

The principle worked, although it was never put into practice by the US authorities. Even factoring in the costs of training them, pigeons are cheaper and lighter than computers of comparable effectiveness. Their feats in Skinner's boxes suggest that a pigeon, after a regimen of training with colour slides, really could guide a missile to a distinctive landmark at the southern end of Manhattan island. The pigeon has no idea that it is guiding a missile. It just keeps on pecking at those two tall rectangles on the screen, from time to time a food reward drops out of the dispenser, and this goes on until... oblivion.

Pigeons may be cheap and disposable as on-board guidance systems, but there's no escaping the cost of the missile itself. And no such missile large enough to do much damage could penetrate US air space without being intercepted. What is needed is a missile that is not recognised for what it is until too late. Something like a large civilian airliner, carrying the innocuous markings of a well-known carrier and a great deal of fuel. That's the easy part. But how do you smuggle on board the necessary guidance system? You can hardly expect the pilots to surrender the left-hand seat to a pigeon or a computer.

How about using humans as on-board guidance systems, instead of pigeons? Humans are at least as numerous as pigeons, their brains are not significantly costlier than pigeon brains, and for many tasks they are actually superior. Humans have a proven track record in taking over planes by the use of threats, which work because the legitimate pilots value their own lives and those of their passengers.

The natural assumption that the hijacker ultimately values his own life too, and will act rationally to preserve it, leads air crews and ground staff to make calculated decisions that would not work with guidance modules lacking a sense of self-preservation. If your plane is being hijacked by an armed man who, though prepared to take risks, presumably wants to go on living, there is room for bargaining. A rational pilot complies with the hijacker's wishes, gets the plane down on the ground, has hot food sent in for the passengers and leaves the negotiations to people trained to negotiate.

The problem with the human guidance system is precisely this. Unlike the pigeon version, it knows that a successful mission culminates in its own destruction. Could we develop a biological guidance system with the compliance and dispensability of a pigeon but with a man's resourcefulness and ability to infiltrate plausibly? What we need, in a nutshell, is a human who doesn't mind being blown up. He'd make the perfect on-board guidance system. But suicide enthusiasts are hard to find. Even terminal cancer patients might lose their nerve when the crash was actually looming.

Could we get some otherwise normal humans and somehow persuade them that they are not going to die as a consequence of flying a plane smack into a skyscraper? If only! Nobody is that stupid, but how about this - it's a long shot, but it just might work. Given that they are certainly going to die, couldn't we sucker them into believing that they are going to come to life again afterwards? Don't be daft! No, listen, it might work. Offer them a fast track to a Great Oasis in the Sky, cooled by everlasting fountains. Harps and wings wouldn't appeal to the sort of young men we need, so tell them there's a special martyr's reward of 72 virgin brides, guaranteed eager and exclusive.

Would they fall for it? Yes, testosterone-sodden young men too unattractive to get a woman in this world might be desperate enough to go for 72 private virgins in the next.

It's a tall story, but worth a try. You'd have to get them young, though. Feed them a complete and self-consistent background mythology to make the big lie sound plausible when it comes. Give them a holy book and make them learn it by heart. Do you know, I really think it might work. As luck would have it, we have just the thing to hand: a ready-made system of mind-control which has been honed over centuries, handed down through generations. Millions of people have been brought up in it. It is called religion and, for reasons which one day we may understand, most people fall for it (nowhere more so than America itself, though the irony passes unnoticed). Now all we need is to round up a few of these faith-heads and give them flying lessons.

Facetious? Trivialising an unspeakable evil? That is the exact opposite of my intention, which is deadly serious and prompted by deep grief and fierce anger. I am trying to call attention to the elephant in the room that everybody is too polite - or too devout - to notice: religion, and specifically the devaluing effect that religion has on human life. I don't mean devaluing the life of others (though it can do that too), but devaluing one's own life. Religion teaches the dangerous nonsense that death is not the end.

If death is final, a rational agent can be expected to value his life highly and be reluctant to risk it. This makes the world a safer place, just as a plane is safer if its hijacker wants to survive. At the other extreme, if a significant number of people convince themselves, or are convinced by their priests, that a martyr's death is equivalent to pressing the hyperspace button and zooming through a wormhole to another universe, it can make the world a very dangerous place. Especially if they also believe that that other universe is a paradisical escape from the tribulations of the real world. Top it off with sincerely believed, if ludicrous and degrading to women, sexual promises, and is it any wonder that naive and frustrated young men are clamouring to be selected for suicide missions?

There is no doubt that the afterlife-obsessed suicidal brain really is a weapon of immense power and danger. It is comparable to a smart missile, and its guidance system is in many respects superior to the most sophisticated electronic brain that money can buy. Yet to a cynical government, organisation, or priesthood, it is very very cheap.

Our leaders have described the recent atrocity with the customary cliche: mindless cowardice. "Mindless" may be a suitable word for the vandalising of a telephone box. It is not helpful for understanding what hit New York on September 11. Those people were not mindless and they were certainly not cowards. On the contrary, they had sufficiently effective minds braced with an insane courage, and it would pay us mightily to understand where that courage came from.

It came from religion. Religion is also, of course, the underlying source of the divisiveness in the Middle East which motivated the use of this deadly weapon in the first place. But that is another story and not my concern here. My concern here is with the weapon itself. To fill a world with religion, or religions of the Abrahamic kind, is like littering the streets with loaded guns. Do not be surprised if they are used.

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Review by Richard Dawkins of Narrow Roads of Gene Land by W.D.Hamilton W.H.Freeman/Spektrum, Oxford, 1996

and

The Song of the Dodo by David Quammen
Article in The Times August, 29 1996

“Imagine a circular lily pond.” The memorable first sentence of W.D.Hamilton’s ‘Geometry for the Selfish Herd’ (equally memorable and utterly characteristic title) presages his simple but productive mathematics. Hamilton is more naturalist and explorer than technical mathematician, but he has the larger imagination of a great mathematician and he is, in my not uninformed opinion, the most innovative evolutionary imaginer since Darwin himself.

He has never published a book before, and nobody has published a book like Narrow Roads of Gene Land. It is (Volume 1 of) his collected papers (‘Geometry for the Selfish Herd’ being one of the less important of them), bound together with an autobiographical thread. Distinguished scientists often publish their collected papers, especially when, unlike Hamilton, they have reached that time of life known as the philosopause, but their papers sometimes turn out to have less in them than one had thought. Hamilton’s papers invariably have more. To reread them is to be continually astonished, not by their main themes – which are now well known and have earned Hamilton the plaudits and prizes of the scientific world – but by their throwaway lines.

The byways of a Hamilton paper, written in his uniquely (for a scientific paper) reflective, meditative prose, are a kind of negative padding. “My God”, we say, “He even thought of so-and-so but never bothered to make anything of it.”. To take just one of these narrow roads for example, there is a theory of the origins of sociality in termites which is universally attributed to an American author whom I shall call B. Quite recently I heard Hamilton referring to B’s theory and I stopped him. “Bill, that isn’t B’s theory. You thought of it first. It’s clearly stated in your 1972 paper.” He denied it Eeyorishly, and I was forced to run to the library to fetch the paper concerned. Only when I thrust his own paragraph under his nose did he gloomily concede that, yes, apparently he had thought of B’s theory nearly a decade before B.

His modesty is legendary, but the autobiographical passages of this book reveal a stubborn belief in the importance of what he was doing even during the wilderness years when scarcely anybody else saw any merit in the questions he was asking – let alone the answers he was discovering. Hamilton was working ten years before his time and that can be a lonely business. “I told you so” is not a naturally Hamiltonian phrase, but we can read it between the lines of his account of obscure and frustrating early years in Cambridge and London.

“Most of the time I was extremely lonely. Sometimes I came to dislike my bedsitting room so much that . . . I would go to Waterloo Station, where I continued reading or trying to write out a model sitting on the benches among waiting passengers in the main hall. . . or on a park bench in the gardens of Chiswick House or at Kew. . . But the beauty and the wild life of these gardens were at least as distracting as was the human pageant at Waterloo (the alcoholics sheltering or craving company like me . . .) Out at Kew I remember . . . only too often, the sun shining too brightly on my pages, the air being too cold, or the wind scattering the reams of my wretched and erroneous algebra across the grass.”

Recognition has now come. Others, in their thousands, are tramping Hamilton’s original narrow roads into broad highways of Kuhnian normal science. Still a prophet but no longer without honour, Hamilton is cutting new trails through the Brazilian jungle and through mathematical gene land. Still alone perhaps, but only in the sense of being without peer. Now he has the company of eager young scientists, anxiously watching to see where their subject is going to be in ten years’ time.

Hamilton’s papers are not easy, and this is not a book that even professionals will necessarily read from cover to cover. But the autobiographical notes form a narrative that can be read on its own. Historians and philosophers of science must study this memoir for professional reasons. The rest of us can just enjoy it and, when we have acquired a taste for Hamilton’s uniquely personal style, we shall recognize snatches of it as we flick over the papers themselves which will lure us in to make the worthwhile effort. Who, after all, could totally resist a paper called “Gamblers since Life Began: Barnacles, Aphids, Elms”?

Imagine – as Hamilton has probably written somewhere – a world without islands. Islands are not just small pieces of land surrounded by water. They are small pieces of anything surrounded by something different, surrounded by whatever serves as a barrier to animal or plant dispersal. To a fish, a lake is an island of water surrounded by land. In the world of the yellow bellied marmot, mountaintops can form an archipelago of islands jutting out of the plain. Islands, and the large consequences of their existence, are the subject of David Quammen's The Song of the Dodo.

A world without islands would be sterile. The Heaven of Rupert Brooke's Fish ("There shall be no more land, say fish") would not be fly-replete, would be destitute of fish themselves. An undissected waterscape, or landscape, deprives gene pools of the opportunity to diverge and form new species. No new species implies, on a larger time scale, no new orders, classes or phyla. Your ancestors and snail ancestors were once races of the same precambrian species, capable of interbreeding. But for some long-vanished barrier between two seas they would be interbreeding still, and evolution could not have progressed. Islands, in the broad sense and on the evolutionary timescale, are the spawning grounds of new species. Without them, life would be a single smear of uniformity or, more probably, extinct.

No wonder islands inspired both Charles Darwin and the co-discoverer of his principle, Alfred Wallace. No wonder islands provoked one of the most influential collaborations of modern ecology, between Edward O.Wilson and the late Robert MacArthur. Quammen gripes against Darwin but the others in this list are his heroes, together with a large collection of young, mostly American, field ecologists for whom he caddies across their various archipelagoes around the world.

You don't have to be American to enjoy this book, but it might help. English readers must grit their teeth through being gratuitously told that our normal way of pronouncing 'neither' is 'snotty'. In retaliation, I could note that Quammen's baseball-hatted cast are forever 'addressing' questions and indulging in that peculiar affectation of American field biologists of both sexes, the "real tough" language of the farm boy. A snake expert dons an old gardening glove because "I don't like being bit". And do you know what a size-nine hellgrammite is? Anything like a linebacker?

Never mind, it is all the more touching when one of these scientific tough guys breaks down in tears at the recollection of one of his favourite islands, now denuded to make a trailer park (caravan site) for Florida sunseekers. Quammen himself gives us a moving elegy for Bedo, boy naturalist of the Madagascar jungles, murdered out of jealousy for his professional success as peerless guide to the world's lemur watchers.

This is, finally, a moving book. It passes from evolution to that other aspect of island faunas, their vulnerability to extinction. Quammen's quest took him to the world's islands and archipelagoes, not to take a last look at the Komodo Dragon or the Mauritius kestrel, but to talk to the experts about why they may go extinct. There is an elaborate theory of island biogeography, of the mathematical equilibrium between colonisation and extinction. There are appropriately tough-talking controversies between rival island biogeographers. Quammen island-hopped around the world, listening patiently to them all, sharing in the privations and not inconsiderable hazards of their fieldwork. He is a science journalist who does not duck the responsibility to convey the complexities and the difficulties of science. Science isn't all fun, and journalists who represent it so diminish the subject and patronise their readers. The book is longer than I would have advised, but David Quammen is a good writer who has taken the trouble to master an important subject and do it justice.

Review of Blueprints: Solving the Mystery of Evolution

New York Times, April 9, 1989
IN SHORT: NONFICTION

Date: April 9, 1989, Sunday, Late City Final Edition Section 7; Page 34, Column 2; Book Review Desk

By RICHARD DAWKINS; Richard Dawkins, a fellow of New College and lecturer in zoology at the University of Oxford, is the author of ''The Blind Watchmaker: Why the
Evidence of Evolution Reveals a Universe Without Design.''
Lead: LEAD: BLUEPRINTS Solving the Mystery of Evolution. By Maitland A. Edey and Donald C. Johanson. Illustrated. 418 pp. Boston: Little, Brown & Company. $19.95.
Text:

BLUEPRINTS Solving the Mystery of Evolution. By Maitland A. Edey and Donald C. Johanson. Illustrated. 418 pp. Boston: Little, Brown & Company. $19.95.

''Do you realize,'' said Don, ''that nearly half the people in the United States don't believe in evolution?'' This sentence epitomizes both the provocation for and the odd provenance of the book under review. To take the latter first, ''Blueprints'' purports to be the joint work of a distinguished scientist and a journalist, Donald C. Johanson and Maitland A. Edey. It is their second collaboration; the first was ''Lucy: The Beginnings of Humankind.'' Such a combination is bound to arouse suspicions of ghostwriting by the journalist, cashing in on the name of the scientist. The difference here is that the ghost manifests himself with unusual frankness. Mr. Johanson enters the book only as Don, a third-person character who occasionally drops in, looks over the author's shoulder and comments on whatever he happens to be working on at the moment. '' 'Those things are called Punnett squares,' said Don, watching as I laboriously completed the large square on the preceding page. 'Boy, are they dull.' ''

In other places, especially in the sections on molecular genetics and bacterial evolution, there is an odd role reversal: ''Don'' comes off as pupil, his colleague as master. ''Mait'' indulges in pedagogical questions like ''Does that suggest anything to you?'' and Don's answer is rewarded with a magisterial ''Right.'' Mr. Johanson, the director of the Institute of Human Origins in Berkeley, Calif., is a fine paleontologist and anthropologist. He has many achievements to his name, but writing this book is not one of them, and I shall henceforth refer to the author in the singular. But it is a shame to carp, for this book should be welcomed by anyone with a love of truth in a dark time. It has an important and true story to tell - the story of evolution. As far as I am able to judge (which is adequately far), the science in the book is accurate and up-to-date. On the whole it is pleasantly written, in spite of the reservations entered above (and a few others: I had earlier promised myself that if I had to endure the silly story about Thomas Henry Huxley's schoolboy triumph over Bishop Wilberforce one more time, I'd scream; and I duly did so).

Following a history of Darwin and his predecessors, the large middle section of the book covers the important science of genetics, from Gregor Mendel through the American geneticist T. H. Morgan to Francis Crick - giving too little credit, for my money, to the English geneticist R. A. Fisher and his colleagues in the 1930's. The section called ''The Origin of Life'' is notable for its courageous attempt (which I have shirked in my own writings) to explain the difficult ideas of the German chemist Manfred Eigen. For me, the most interesting chapter is the one devoted to the work of the American bacteriologist Carl R. Woese because it deals with the earliest phases of evolution, the split between our remotest cousins, the archaebacteria, and all the rest of us.

The chapters on human evolution display predictable expertise on fossils, but it is also good to see Mr. Johanson's arid home ground irrigated by a refreshing trickle of molecular evidence, and particularly gratifying to find at last proper recognition of the enormously important work of the American biochemist Vincent Sarich. Contrary to the erstwhile conclusions of all paleontologists, we now know from the work of Mr. Sarich and his colleague, the molecular biologist Allan Wilson, that our common ancestor with chimpanzees lived astonishingly recently. Moreover, we are closer cousins to African apes (chimpanzees and gorillas) than those apes are to other apes (orangutans and gibbons). We are not, then, merely like apes or descended from apes; we are apes, and African apes at that. The final chapter, a reflection on extinction and the dangers of being too smart, moves toward being noticeably well written. Mr. Edey may call himself a journalist, but he evidently is a pretty high-class journalist.

So to the book's provocation, the statement that nearly half the people in the United States don't believe in evolution. Not just any people but powerful people, people who should know better, people with too much influence over educational policy. We are not talking about Darwin's particular theory of natural selection. It is still (just) possible for a biologist to doubt its importance, and a few claim to. No, we are here talking about the fact of evolution itself, a fact that is proved utterly beyond reasonable doubt. To claim equal time for creation science in biology classes is about as sensible as to claim equal time for the flat-earth theory in astronomy classes. Or, as someone has pointed out, you might as well claim equal time in sex education classes for the stork theory. It is absolutely safe to say that if you meet somebody who claims not to believe in evolution, that person is ignorant, stupid or insane (or wicked, but I'd rather not consider that).

If that gives you offense, I'm sorry. You are probably not stupid, insane or wicked; and ignorance is no crime in a country with strong local traditions of interference in the freedom of biology educators to teach the central theorem of their subject. I recently toured East Coast radio stations, doing phone-ins. I came away optimistic. I had expected hostile barracking from creationists with closed minds. Instead, what I found was genuine curiosity and honest interest. I got sincere questions from intelligent people who really wanted to know because they had literally no education in evolution.

I don't think it is too melodramatic to say that civilization is at war. It is a war against religious bigotry. In Britain recently our newspapers have shown crowds of fundamentalists (they happen to be Muslim rather than Christian, but in this context the distinction is of no importance) baying for the death of the distinguished novelist Salman Rushdie, displaying his effigy with its eyes put out and publicly burning his books. The truly appalling thing all such people have in common, whether they are incited to murder by ayatollahs or to less violent observances by television evangelists, is that they know, for certain, that their particular brand of revealed truth is absolute and needs no reasoned defense. In Iran I don't suppose evolution is even an issue, but in the United States a case can be made that it is right there on the front line.

If you feel even vaguely in the mood to stand up and be counted, evolution is a pretty good issue on which to take your stand. It is an excellent standard-bearer for reason and the gentle virtues of civilization. This is because the more you read, quietly and soberly, the evidence for evolution, the more powerful will you discover that evidence to be. You are as safe taking your stand on the fact of evolution as you would be on the fact that the earth goes round the sun. But the latter is not - any longer - at stake in the war against fundamentalism. Evolution is on the front line because it is an important issue disputed by fundamentalists, and you can be completely confident that you can easily prove them wrong.

''Blueprints'' is not the only book, and probably not the best book, in which you may locate the ammunition. Even in time of war one should not suppress criticism of one's own side, and I haven't done so. But this is an honest book, telling the truth in an area where half the country claims to believe an absurd and palpable falsehood. I say ''claims'' because a belief that is held in carefully nurtured ignorance of the alternative is hardly a belief to be taken seriously. For all its faults, ''Blueprints'' is about more important matters than many a book you will find displayed in your bookshop or, I dare say, reviewed in these pages.

HomeSite

Review of Richard Milton: The Facts of Life: Shattering the myth of Darwinism. Published in New Statesman, (London), 28th August 1992.

Every day I get letters, in capitals and obsessively underlined if not actually in green ink, from flat-earthers, young-earthers, perpetual-motion merchants, astrologers and other harmless fruitcakes. The only difference here is that Richard Milton managed to get his stuff published. The publisher - we don't know how many decent publishers turned it down first - is called 'Fourth Estate.' Not a house that I had heard of, but apparently neither a vanity press nor a fundamentalist front. So, what are 'Fourth Estate' playing at? Would they publish - for this book is approximately as silly - a claim that the Romans never existed and the Latin language is a cunning Victorian fabrication to keep schoolmasters employed?

A cynic might note that there is a paying public out there, hungry for simple religious certitude, who will lap up anything with a subtitle like 'Shattering the Myth of Darwinism.' If the author pretends not to be religious himself, so much the better, for he can then be exhibited as an unbiased witness. There is - no doubt about it - a fast buck to be made by any publishers unscrupulous enough to print pseudoscience that they know is rubbish but for which there is a market.

But let's not be so cynical. Mightn't the publishers have an honourable defence? Perhaps this unqualified hack is a solitary genius, the only soldier in the entire platoon - nay, regiment - who is in step. Perhaps the world really did bounce into existence in 8000 BC. Perhaps the whole vast edifice of orthodox science really is totally and utterly off its trolley. (In the present case, it would have to be not just orthodox biology but physics, geology and cosmology too). How do we poor publishers know until we have printed the book and seen it panned?

If you find that plea persuasive, think again. It could be used to justify publishing literally anything; flat-earth, fairies, astrology, werewolves and all. It is true that an occasional lonely figure, originally written off as loony or at least wrong, has eventually been triumphantly vindicated (though not often a journalist like Richard Milton, it has to be said). But it is also true that a much larger number of people originally regarded as wrong really were wrong. To be worth publishing, a book must do a little more than just be out of step with the rest of the world.

But, the wretched publisher might plead, how are we, in our ignorance, to decide? Well, the first thing you might do - it might even pay you, given the current runaway success of some science books - is employ an editor with a smattering of scientific education. It needn't be much: A-level Biology would have been ample to see off Richard Milton. At a more serious level, there are lots of smart young science graduates who would love a career in publishing (and their jacket blurbs would avoid egregious howlers like calling Darwinism the "idea that chance is the mechanism of evolution.") As a last resort you could even do what proper publishers do and send the stuff out to referees. After all, if you were offered a manuscript claiming that Tennyson wrote The Iliad, wouldn't you consult somebody, say with an O-level in History, before rushing into print?

You might also glance for a second at the credentials of the author. If he is an unknown journalist, innocent of qualifications to write his book, you don't have to reject it out of hand but you might be more than usually anxious to show it to referees who do have some credentials. Acceptance need not, of course, depend on the referees' endorsing the author's thesis: a serious dissenting opinion can deserve to be heard. But referees will save you the embarrassment of putting your imprint on twaddle that betrays, on almost every page, complete and total pig-ignorance of the subject at hand.

All qualified physicists, biologists, cosmologists and geologists agree, on the basis of massive, mutually corroborating evidence, that the earth's age is at least four billion years. Richard Milton thinks it is only a few thousand years old, on the authority of various Creation 'science' sources including the notorious Henry Morris (Milton himself claims not to be religious, and he affects not to recognise the company he is keeping). The great Francis Crick (himself not averse to rocking boats) recently remarked that "anyone who believes that the earth is less than 10,000 years old needs psychiatric help." Yes yes, maybe Crick and the rest of us are all wrong and Milton, an untrained amateur with a 'background' as an engineer, will one day have the last laugh. Want a bet?

Milton misunderstands the first thing about natural selection. He thinks the phrase refers to selection among species. In fact, modern Darwinians agree with Darwin himself that natural selection chooses among individuals within species. Such a fundamental misunderstanding would be bound to have far-reaching consequences; and they duly make nonsense of several sections of the book.

In genetics, the word ‘recessive’ has a precise meaning, known to every school biologist. It means a gene whose effect is masked by another (dominant) gene at the same locus. Now it also happens that large stretches of chromosomes are inert - untranslated. This kind of inertness has not the smallest connection with the ‘recessive’ kind. Yet Milton manages the feat of confusing the two. Any slightly qualified referee would have picked up this clanger.

There are other errors from which any reader capable of thought would have saved this book. Stating correctly that Immanuel Velikovsky was ridiculed in his own time, Milton goes on to say "Today, only forty years later, a concept closely similar to Velikovsky’s is widely accepted by many geologists - that the major extinction at the end of the Cretaceous ... was caused by collison with a giant meteor or even asteroid." But the whole point of Velikovsky (indeed, the whole reason why Milton, with his eccentric views on the age of the earth, champions him) is that his collision was supposed to have happened recently; recently enough to explain Biblical catastrophes like Moses’s parting of the Red Sea. The geologists’ meteorite, on the other hand, is supposed to have impacted 65 million years ago! There is a difference - approximately 65 million years difference. If Velikovsky had placed his collision tens of millions of years ago he would not have been ridiculed. To represent him as a misjudged, wilderness-figure who has finally come into his own is either disingenuous or - more charitably and plausibly - stupid.

In these post-Leakey, post-Johanson days, creationist preachers are having to learn that there is no mileage in ‘missing links.’ Far from being missing, the fossil links between modern humans and our ape ancestors now constitute an elegantly continuous series. Richard Milton, however, still hasn’t got the message. For him, "...the only ‘missing link’ so far discovered remains the bogus Piltdown Man." Australopithecus, correctly described as a human body with an ape’s head, doesn’t qualify because it is ‘really’ an ape. And Homo habilis - ‘handy man’ - which has a brain "perhaps only half the size of the average modern human’s" is ruled out from the other side: "... the fact remains that handy man is a human - not a missing link." One is left wondering what a fossil has to do - what more could a fossil do - to qualify as a ‘missing link’?

No matter how continuous a fossil series may be, the conventions of zoological nomenclature will always impose discontinuous names. At present, there are only two generic names to spread over all the hominids. The more ape-like ones are shoved into the genus Australopithecus; the more human ones into the genus Homo. Intermediates are saddled with one name or the other. This would still be true if the series were as smoothly continuous as you can possibly imagine. So, when Milton says, of Johanson’s ‘Lucy’ and associated fossils, "the finds have been referred to either Australopithecus and hence are apes, or Homo and hence are human," he is saying something (rather dull) about naming conventions, nothing at all about the real world.

But this is a more sophisticated criticism than Milton’s book deserves. The only serious question raised by its publication is why. As for would-be purchasers, if you want this sort of silly-season drivel you’d be better off with a couple of Jehovah’s Witness tracts. They are more amusing to read, they have rather sweet pictures, and they put their religious cards on the table.

Richard Dawkins

http://www.alternativescience.com

The Third Culture

[3.13.00]

RICHARD DAWKINS ON W.D. HAMILTON (1936-2000)

W. D. Hamilton (1936 - 2000)

W D Hamilton is a good candidate for the title of most distinguished Darwinian since Darwin. Other candidates would have to include R A Fisher, whom Hamilton revered as a young student at Cambridge. Hamilton resembled Fisher in his penetrating biological intuition and his ability to render it in mathematics. But, like Darwin and unlike Fisher, he was also a superb field naturalist and explorer. I suspect that, of all his twentieth century successors, Darwin would most have enjoyed talking to Hamilton. Partly because they could have swapped jungle tales and beetle lore, partly because both were gentle and deep, but mostly because Hamilton the theorist was responsible for clearing up so many of the very problems that had intrigued and tantalised Darwin.

William Donald Hamilton FRS was Royal Society Research Professor in the Department of Zoology at Oxford, and a Professorial Fellow of New College. He was born in 1936, spent a happy childhood botanising and collecting butterflies in Kent, was educated at Tonbridge, then Cambridge where he read Genetics. For his Ph.D. he moved to London where he was jointly enrolled at University College and LSE. He became a Lecturer at Imperial College in 1964, where his teaching skills were not highly rated. After a brief Visiting Professorship at Harvard, he accepted a Museum Professorship at the University of Michigan in 1977. Finally, in 1984 he moved to Oxford at the invitation of Richard Southwood, who had been his Professor at Imperial.

Hamilton was showered with medals and honours by the academies and learned societies of the world. He won the Kyoto Prize, the Fyssen Prize, the Wander Prize, and the Crafoord Prize - instituted by the Swedish Academy because Alfred Nobel unaccountably failed to include non-medical Biology in his list of eligible subjects. But honours and recognition did not come early. The autobiographical chapters of Hamilton's collection of papers, Narrow Roads of Gene Land, reveal a lonely young man driven to self-doubt by lack of comprehension among his peers and superiors. To epitomise the Cambridge of his undergraduate days, where "many biologists hardly seemed to believe in evolution" he quotes one senior professor: "Insects do not live for themselves alone. Their lives are devoted to the survival of the species . . ." This is "Group Selection", a solecism which would cause today's biology undergraduates to wince, but they have the advantage of a post-Hamilton education. The young Hamilton felt that in Cambridge he was wincing alone. Only the cantankerous Fisher made sense to him, and he had been advised that Fisher "was good with statistics but knew nothing about biology."

For his doctoral work he proposed a difficult mathematical model with a simple conclusion now known as "Hamilton's Rule." It states that a gene for altruistic self sacrifice will spread through a population if the cost to the altruist is outweighed by the benefit to the recipient devalued by a fraction representing the genetic relatedness between the two. Hamilton's original paper was so difficult and innovative that it almost failed to be published, and was largely ignored for a decade. When finally noticed, its influence spread exponentially until it became one of the most cited papers in all of biology. It is the key to understanding half the altruistic cooperation in nature. The key to the other half - reciprocation among unrelated individuals - is a theory to which Hamilton was later to make a major contribution, in collaboration with the social scientist Robert Axelrod.

The great obsession of his later career was parasites - their evolutionary rather than their medical impact. Over twenty years, Hamilton convinced more and more biologists that parasites are the key to many outstanding problems left by Darwin, including the baffling riddle of the evolution of sex. The sexual shuffling of the genetic pack is an elaborate trick for outrunning parasites in the endless race through evolutionary time. This work led Hamilton into the arcane world of computer simulation, where his models were as richly textured, in their way, as his beloved Brazilian jungle. His spin off theory of sexual selection (how Darwin would have relished it!) was that bird of paradise tails and similar male extravaganzas are driven by the evolution of female diagnostic skills: females are like sceptical doctors, actively seeking parasite-free males to supply genes for their shared posterity. Male advertisement is an honest boast of health.

Hamilton's mathematical models never became arid; they were laced with, and often inspired by, bizarre natural history. Would that every mathematical lump were leavened, as Hamilton's were, by eye-witness accounts of, say, the male mite who copulates with all his sisters and then dies before any of them are born. Or of aphid females who give live birth to their daughters and granddaughters simultaneously.

For most scientists, good ideas are a scarce commodity, to be milked for everything they are worth. Hamilton, by contrast, would bury, in little throwaway asides, ideas for which others would kill. Sometimes he buried them so deeply that he overlooked them himself. Extreme social life in termites poses a particular evolutionary problem not shared by the equally social ants, bees and wasps. An ingenious theory exists, widely attributed to an author whom I shall call X. Hamilton and I were once talking termites, and he spoke favourably of X's theory. "But Bill", I protested, "That isn't X's theory. It's your theory. You thought of it first." He gloomily denied it, so I asked him to wait while I ran to the library. I returned with a bound journal volume and shoved under his nose his own discreetly buried paragraph on termites. Eeyorishly, he conceded that, yes, it did appear to be his own theory after all, but X had explained it much better. In a world where scientists vie for priority, Hamilton was endearingly unique.

Those who loved him saw a Felix with nine lives. Charmingly accident-prone, Bill would always bounce back. A childhood experiment with explosives cost him several finger joints of his right hand. He was frequently knocked off his bicycle, probably because of misjudgements by Oxford motorists who couldn't believe a man of his age with a great shock of white hair could possibly cycle so fast. And he travelled dangerously in wilder and more remote places than Oxford. He hiked through Rwanda at the height of the civil war, and was treated as a spy, so implausible was his (true) story that he was looking for ants. Held up at knife point in Brazil, he made the mistake of fighting back, and was viciously wounded. He jumped into an Amazon tributary when his boat was sinking, in order to plug the hole, like the little Dutch boy, with his thumb (the ferocity of Piranha fish, he explained, is over-rated). Finally, to gather indirect evidence for the theory (of which he was a strong supporter) that the AIDS virus was originally introduced into the human population in an oral polio vaccine tested in Africa in the 1950s, Hamilton went, with two brave companions, to the depths of the Congo jungle in January this year. He was rushed back to London, apparently with severe malaria, seemed to recover, then collapsed into complications and coma. This time, he didn't bounce back.

He is survived by his wife, Christine, from whom he had been amicably separated for some time, by their three daughters Helen, Ruth and Rowena, and by his devoted companion of recent years, Luisa Bozzi.

RICHARD DAWKINS

(This obituary also appeared in The Independent - 3.10.2000)

RICHARD DAWKINS is an evolutionary biologist and the Charles Simonyi Professor For The Understanding Of Science at Oxford University; Fellow of New College; author of The Selfish Gene,The Extended Phenotype,The Blind Watchmaker, River Out Of Eden (Science Masters Series), Climbing Mount Improbable, and Unweaving The Rainbow.

SCIENCE AND SENSIBILITY

Richard Dawkins

Queen Elizabeth Hall Lecture, London, 24th March 1998. Series title: Sounding the Century (‘What will the Twentieth Century leave to its heirs?’)

With trepidation and humility, I find myself the only scientist in this list of lecturers. Does it really fall to me alone to ‘sound the century’ for science; to reflect on the science that we bequeath to our heirs? The twentieth could be science’s golden century: the age of Einstein, Hawking and relativity; of Planck, Heisenberg and Quantum Theory; of Watson, Crick, Sanger and molecular biology; of Turing, von Neumann and the computer; of Wiener, Shannon and cybernetics, of Plate Tectonics and radioactive dating of the rocks; of Hubble’s Red Shift and the Hubble Telescope; of Fleming, Florey and penicillin; of moon landings, and – let’s not duck the issue – of the hydrogen bomb. As George Steiner noted in the previous lecture, more scientists are working today than in all other centuries combined. Though also – to put that figure into alarming perspective – more people are alive today than have died since the dawn of Homo sapiens.

Of the dictionary meanings of sensibility, I intend "discernment, awareness" and "the capacity for responding to aesthetic stimuli". One might have hoped that, by century’s end, science would have been incorporated into our culture, and our aesthetic sense have risen to meet the poetry of science. Without reviving the mid-century pessimism of C P Snow, I reluctantly find that, with only two years to run, these hopes are not realised. Science provokes more hostility than ever, sometimes with good reason, often from people who know nothing about it and use their hostility as an excuse not to learn. Depressingly many people still fall for the discredited clichŽ that scientific explanation corrodes poetic sensibility. Astrology books outsell astronomy. Television beats a path to the door of second rate conjurors masquerading as psychics and clairvoyants. Cult leaders mine the millennium and find rich seams of gullibility: Heaven’s Gate, Waco, poison gas in the Tokyo underground. The biggest difference from the last millennium is that folk Christianity has been joined by folk science-fiction.

It should have been so different. The previous millennium, there was some excuse. In 1066, if only with hindsight, Halley’s Comet could forebode Hastings, sealing Harold’s fate and Duke William’s victory. Hale-Bopp in 1997 should have been different. Why do we feel gratitude when a newspaper astrologer reassures his readers that Hale-Bopp was not directly responsible for Princess Diana’s death? And what is going on when 39 people, driven by a theology compounded of Star Trek and the Book of Revelations, commit collective suicide, neatly dressed and with overnight bags packed by their sides, because they all believed that Hale-Bopp was accompanied by a spaceship come to "raise them to a new plane of existence"? Incidentally, the same Heaven’s Gate Commune had ordered an astronomical telescope to look at Hale-Bopp. They sent it back when it came, because it was obviously defective: it failed to show the accompanying spaceship.

Hijacking by pseudoscience and bad science fiction is a threat to our legitimate sense of wonder. Hostility from academics sophisticated in fashionable disciplines is another, and I shall return to this. Populist ‘dumbing down’ is a third. The ‘Public Understanding of Science’ movement, provoked in America by Sputnik and driven in Britain by alarm over a decline in science applicants at universities, is going demotic. A spate of ‘Science Fortnights’ and the like betrays a desperate anxiety among scientists to be loved. Whacky ‘personalities’, with funny hats and larky voices, perform explosions and funky tricks to show that science is fun, fun, fun..

I recently attended a briefing session urging scientists to put on ‘events’ in shopping malls, designed to lure people into the joys of science. We were advised to do nothing that might conceivably be a ‘turn-off’. Always make your science ‘relevant’ to ordinary people – to what goes on in their own kitchen or bathroom. If possible, choose experimental materials that your audience can eat at the end. At the last event organized by the speaker himself, the scientific feat that really grabbed attention was the urinal, which automatically flushed as soon as you stepped away. The very word science is best avoided, because ‘ordinary people’ find it threatening.

When I protest, I am rebuked for my ‘elitism’. A terrible word, but maybe not such a terrible thing? There’s a great difference between an exclusive snobbery, which no-one should condone, and a striving to help people raise their game and swell the elite. A calculated dumbing down is the worst, condescending and patronising. When I said this in a recent lecture in the United States, a questioner at the end, no doubt with a warm glow in his white male heart, had the remarkable cheek to suggest that ‘fun’ might be especially necessary to bring ‘minorities and women’ to science.

I worry that to promote science as all larky and easy is to store up trouble for the future. Recruiting advertisements for the army don’t promise a picnic, for the same reason. Real science can be hard but, like classical literature or playing the violin, worth the struggle. If children are lured into science, or any other worthwhile occupation, by the promise of easy frolics, what happens when they finally confront the reality? ‘Fun’ sends the wrong signals and might attract recruits for the wrong reasons.

Literary studies are at risk of becoming similarly undermined. Idle students are seduced into a debased ‘Cultural Studies’, where they will spend their time ‘deconstructing’ soap operas, tabloid princesses, and tellytubbies. Science, like proper literary studies, can be hard and challenging but science is – again like proper literary studies – wonderful. Science is also useful; but useful is not all it is. Science can pay its way but, like great art, it shouldn’t have to. And we shouldn’t need whacky personalities and explosions to persuade us of the value of a life spent finding out why we have life in the first place.

Perhaps I’m being too negative, but there are times when a pendulum has swung too far and needs a push in the other direction. Certainly, practical demonstrations can make ideas vivid and preserve them in the mind. From Michael Faraday’s Royal Institution Christmas Lectures, to Richard Gregory’s Bristol Exploratory, children have been excited by hands-on experience of true science. I was myself honoured to give the Christmas Lectures, in their modern televised form, with plenty of hands-on demonstrations. Faraday never dumbed down. I am attacking only the kind of populist whoring that defiles the wonder of science.

Annually in London there is a large dinner, at which prizes for the year’s best science books are presented. One prize is for children’s science books, and it recently went to a book about insects and other so-called ‘ugly bugs.’ Such language is not best calculated to arouse the poetic sense of wonder, but let that pass. Harder to forgive were the antics of the Chairman of the Judges, a well known television personality (who had credentials to present real science, before she sold out to ‘paranormal’ television). Squeaking with game-show levity, she incited the audience to join her in repeated choruses of audible grimaces at the contemplation of the horrible ‘ugly bugs’. "Eeeuurrrgh! Yuck! Yeeyuck! Eeeeeuurrrgh!" That kind of vulgarity demeans the wonder of science, and risks ‘turning off’ the very people best qualified to appreciate it and inspire others: real poets and true scholars of literature.

The true poetry of science, especially 20th century science, led the late Carl Sagan to ask the following acute question.

"How is it that hardly any major religion has looked at science and concluded, ‘This is better than we thought! The Universe is much bigger than our prophets said, grander, more subtle, more elegant’? Instead they say, ‘No, no, no! My god is a little god, and I want him to stay that way.’ A religion, old or new, that stressed the magnificence of the Universe as revealed by modern science might be able to draw forth reserves of reverence and awe hardly tapped by the conventional faiths."

Given a hundred clones of Carl Sagan, we might have some hope for the next century. Meanwhile, in its closing years, the twentieth must be rated a disappointment as far as public understanding of science is concerned, while being a spectacular and unprecedented success with respect to scientific achievements themselves.

What if we let our sensibility play over the whole of 20th century science. Is it possible to pick out a theme, a scientific leitmotif? My best candidate comes nowhere near doing justice to the richness on offer. The twentieth is The Digital Century. Digital discontinuity pervades the engineering of our time, but there is a sense in which it spills over into the biology and perhaps even the physics of our century.

The opposite of digital is analogue. When the Spanish Armada was expected, a signalling system was devised to spread the news across southern England. Bonfires were set on a chain of hilltops. When any coastal observer spotted the Armada he was to light his fire. It would be seen by neighbouring observers, their fires would be lit, and a wave of beacons would spread the news at great speed far along the coastal counties.

How could we adapt the bonfire telegraph to convey more information? Not just "The Spanish are here" but, say, the size of their fleet? Here’s one way. Make your bonfire’s size proportional to the size of the fleet. This is an analogue code. Clearly, inaccuracies would be cumulative. So, by the time the message reached the other side of the kingdom, the information about fleet size would have degraded to nothing. This is a general problem with analogue codes.

But now here’s a simple digital code. Never mind the size of the fire, just build any serviceable blaze and place a large screen around it. Lift the screen and lower it again, to send the next hill a discrete flash. Repeat the flash a particular number of times, then lower the screen for a period of darkness. Repeat. The number of flashes per burst should be made proportional to the size of the fleet.

This digital code has huge virtues over the previous analogue code. If a hilltop observer sees eight flashes, eight flashes is what he passes along to the next hill in the chain. The message has a good chance of spreading from Plymouth to Dover without serious degradation. The superior power of digital codes has been clearly understood only in the twentieth century.

Nerve cells are like armada beacons. They ‘fire’. What travels along a nerve fibre is not electric current. It’s more like a trail of gunpowder laid along the ground. Ignite one end with a spark, and the fire fizzes along to the other end.

We’ve long known that nerve fibres don’t use purely analogue codes. Theoretical calculations show that they couldn’t. Instead, they do something more like my flashing Armada beacons. Nerve impulses are trains of voltage spikes, repeated as in a machine gun. The difference between a strong message and a weak is not conveyed by the height of the spikes – that would be an analogue code and the message would be distorted out of existence. It is conveyed by the pattern of spikes, especially the firing rate of the machine gun. When you see yellow or hear Middle C, when you smell turpentine or touch satin, when you feel hot or cold, the differences are being rendered, somewhere in your nervous system, by different rates of machine gun pulses. The brain, if we could listen in, would sound like Passchendaele. In our meaning, it is digital. In a fuller sense it is still partly analogue: rate of firing is a continuously varying quantity. Fully digital codes, like Morse, or computer codes, where pulse patterns form a discrete alphabet, are even more reliable.

If nerves carry information about the world as it is now, genes are a coded description of the distant past. This insight follows from the selfish gene view of evolution.

Living organisms are beautifully built to survive and reproduce in their environments. Or that is what Darwinians say. But actually it isn’t quite right. They are beautifully built for survival in their ancestors’ environments. It is because their ancestors survived – long enough to pass on their DNA – that our modern animals are well-built. For they inherit the very same successful DNA. The genes that survive down the generations add up, in effect, to a description of what it took to survive back then. And that is tantamount to saying that modern DNA is a coded description of the environments in which ancestors survived. A survival manual is handed down the generations. A genetic Book of the Dead.

Like the longest chain of beacon fires, the generations are uncountably many. No surprise, then, that genes are digital. Theoretically the ancient book of DNA could have been analogue. But, for the same reason as for our analogue armada beacons, any ancient book copied and recopied in analogue language would degrade to meaninglessness in very few scribe generations. Fortunately, human writing is digital, at least in the sense we care about here. And the same is true of the DNA books of ancestral wisdom that we carry around inside us. Genes are digital, and in the full sense not shared by nerves.

Digital genetics was discovered in the nineteenth century, but Gregor Mendel was ahead of his time and ignored. The only serious error in Darwin’s world-view derived from the conventional wisdom of his age, that inheritance was ‘blending’ – analogue genetics. It was dimly realised in Darwin’s time that analogue genetics was incompatible with his whole theory of natural selection. Less clearly realised, it was also incompatible with obvious facts of inheritance. The solution had to wait for the 20th century, especially the neo-Darwinian synthesis of Ronald Fisher and others in the 1930s. The essential difference between classical Darwinism (which we now understand could not have worked) and neo-Darwinism (which does) is that digital genetics has replaced analogue.

But when it comes to digital genetics, Fisher and his colleagues of the Synthesis didn't know the half of it. Watson and Crick opened floodgates to what has been, by any standards, a spectacular intellectual revolution – even if Peter Medawar was going too far when he wrote, in his review of Watson's The Double Helix,

"It is simply not worth arguing with anyone so obtuse as not to realise that this complex of discoveries is the greatest achievement of science in the twentieth century."

My misgiving, about this engagingly calculated piece of arrogance, is that I'd have a hard time defending it against a rival claim for, say, quantum theory or relativity.

Watson and Crick's was a digital revolution and it has gone exponential since 1953. You can read a gene today, write it out precisely on a piece of paper, put it in a library, then at any time in the future reconstitute that exact gene and put it back into an animal or plant. When the human genome project is completed, probably around 2003, it will be possible to write the entire human genome on a couple of standard compact discs, with enough space over for a large textbook of explanation. Send the boxed set of two CDs out into deep space and the human race can go extinct, happy in the knowledge that there is now at least a sporting chance for an alien civilisation to reconstitute a living human being. In one respect (though not in another), my speculation is at least more plausible than the plot of Jurassic Park. And both speculations rest upon the digital accuracy of DNA.

Of course, digital theory has been most fully worked out not by neurobiologists or geneticists, but by electronic engineers. The digital telephones, televisions, music reproducers and microwave beams of the late twentieth century are incomparably faster and more accurate than their analogue forerunners, and this is critically because they are digital. Digital computers are the crowning achievement of this electronic age, and they are heavily implicated in telephone switching, satellite communications and data transmission of all kinds, including that phenomenon of the present decade, the World Wide Web. The late Christopher Evans summed up the speed of the twentieth century digital revolution with a striking analogy to the car industry.

"Today's car differs from those of the immediate post-war years on a number of counts. . . But suppose for a moment that the automobile industry had developed at the same rate as computers and over the same period: how much cheaper and more efficient would the current models be? If you have not already heard the analogy the answer is shattering. Today you would be able to buy a Rolls-Royce for £1.35, it would do three million miles to the gallon, and it would deliver enough power to drive the Queen Elizabeth II. And if you were interested in miniaturization, you could place half a dozen of them on a pinhead."

It is computers that make us notice that the twentieth century is the digital century – lead us to spot the digital in genetics, neurobiology and – though here I lack the confidence of knowledge – physics.

For it could be argued that quantum theory – the part of physics most distinctive of the twentieth century – is fundamentally digital. The Scottish chemist Graham Cairns-Smith tells how he was first exposed to this apparent graininess:

I suppose I was about eight when my father told me that nobody knew what electricity was. I went to school the next day, I remember, and made this information generally available to my friends. It did not create the kind of sensation I had been banking on, although it caught the attention of one whose father worked at the local power station. His father actually made electricity so obviously he would know what it was. My friend promised to ask and report back. Well, eventually he did and I cannot say I was much impressed with the result. 'Wee sandy stuff' he said, rubbing his thumb and forefinger together to emphasise just how tiny the grains were. He seemed unable to elaborate further.

The experimental predictions of quantum theory are upheld to the tenth place of decimals. Any theory with such a spectacular grasp on reality commands our respect. But whether we conclude that the universe itself is grainy – or that discontinuity is forced upon an underlying deep continuity only when we try to measure it – I do not know; and physicists present will sense that the matter is too deep for me.

It should not be necessary to add that this gives me no satisfaction. But sadly there are literary and journalistic circles in which ignorance or incomprehension of science is boasted with pride and even glee. I have made the point often enough to sound plaintive. So let me quote, instead, one of the most justly respected commentators on today's culture, Melvyn Bragg:-

There are still those who are affected enough to say they know nothing about the sciences as if this somehow makes them superior. What it makes them is rather silly, and it puts them at the fag end of that tired old British tradition of intellectual snobbery which considers all knowledge, especially science, as "trade."

Sir Peter Medawar, that swashbuckling, Nobel Prize-winner whom I've already quoted, said something similar about 'trade'.

It is said that in ancient China the mandarins allowed their fingernails – or anyhow one of them – to grow so extremely long as manifestly to unfit them for any manual activity, thus making it perfectly clear to all that they were creatures too refined and elevated ever to engage in such employments. It is a gesture that cannot but appeal to the English, who surpass all other nations in snobbishness; our fastidious distaste for the applied sciences and for trade has played a large part in bringing England to the position in the world which she occupies today.

So, if I have difficulties with quantum theory, it is not for want of trying and certainly not a source of pride. As an evolutionist, I endorse Steven Pinker's view, that Darwinian natural selection has designed our brains to understand the slow dynamics of large objects on the African savannahs. Perhaps somebody should devise a computer game, in which bats and balls behave according to a screened illusion of quantum dynamics. Children brought up on such a game might find modern physics no more impenetrable than we find the concept of stalking a wildebeest.

Personal uncertainty about the uncertainty principle reminds me of another hallmark that will be alleged for twentieth century science. This is the century, it will be claimed, in which the deterministic confidence of the previous one was shattered. Partly by quantum theory. Partly by chaos (in the trendy, not the ordinary language, meaning). And partly by relativism (cultural relativism, not the sensible, Einsteinian meaning).

Quantum uncertainty, and chaos theory, have had deplorable effects upon popular culture, much to the annoyance of genuine aficionados. Both are regularly exploited by obscurantists, ranging from professional quacks to daffy New-Agers. In America, the self-help 'healing' industry coins millions, and it has not been slow to cash in on quantum theory's formidable talent to bewilder. This has been documented by the American physicist Victor Stenger. One well-heeled healer wrote a string of best-selling books on what he calls 'Quantum Healing." Another book in my possession has sections on Quantum psychology, quantum responsibility, quantum morality, quantum aesthetics, quantum immortality, and quantum theology.

Chaos theory, a more recent invention, is equally fertile ground for those with a bent for abusing sense. It is unfortunately named, for 'chaos' implies randomness. Chaos in the technical sense is not random at all. It is completely determined, but it depends hugely, in strangely hard-to-predict ways, on tiny differences in initial conditions. Undoubtedly it is mathematically interesting. If it impinges on the real world, it would rule out ultimate prediction. If the weather is technically chaotic, weather forecasting in detail becomes impossible. Major events like hurricanes might be determined by tiny causes in the past – such as the now proverbial flap of a butterfly's wing. This does not mean that you can flap the equivalent of a wing and hope to generate a hurricane. As the physicist Robert Park says, this is "a total misunderstanding of what chaos is about . . . while the flapping of a butterfly's wings might conceivably trigger a hurricane, killing butterflies is unlikely to reduce the incidence of hurricanes."

Quantum theory and chaos theory, each in their own peculiar ways, may call into question the predictability of the universe, in deep principle. This could be seen as a retreat from nineteenth century confidence. But nobody really thought that such fine details would ever be predicted in practice, anyway. The most confident determinist would always have admitted that, in practice, sheer complexity of interacting causes would defeat accurate prediction of weather or turbulence. So chaos doesn't make a lot of difference in practice. Conversely, quantum events are statistically smothered, and massively so, in most realms that impinge on us. So the possibility of prediction is, for practical purposes, restored.

In the late twentieth century, prediction of future events in practice has never been more confident or more accurate. This is dramatic in the feats of space engineers. Previous centuries could predict the return of Halley's Comet. Twentieth century science can hurl a projectile along the right trajectory to intercept it, precisely computing and exploiting the gravitational slings of the solar system. Quantum theory itself, whatever the indeterminacy at its heart, is spectacularly accurate in the experimental accuracy of its predictions. The late Richard Feynman assessed this accuracy as equivalent to knowing the distance between New York and Los Angeles to the width of one human hair. Here is no licence for anything-goes, intellectual flappers, with their quantum theology and quantum you-name-it.

Cultural relativism is the most pernicious of these myths of twentieth century retreat from Victorian certainty. A modish fad sees science as only one of many cultural myths, no more true nor valid than the myths of any other culture. In the United States it is fed by justified guilt over the appalling treatment of Native Americans. But the consequences can be laughable; as in the case of Kennewick Man.

Kennewick Man is a skeleton discovered in Washington State in 1996, carbon-dated to older than 9000 years. Anthropologists were intrigued by anatomical suggestions that he might be unrelated to typical Native Americans, and might represent a separate early migration across what is now the Bering Strait, or even from Iceland. They were about to do all-important DNA tests when the legal authorities seized the skeleton, intending to hand it over to representatives of local Indian tribes, who proposed to bury it and forbid all further study. Naturally there was widespread opposition from the scientific and archaeological community. What if Kennewick Man is an American Indian of some kind, it is highly unlikely that his affinities lie with whichever particular tribe happens to live in the same area 9000 years later.

Native Americans have impressive legal muscle, and ‘The Ancient One’ might have been handed over to the tribes, but for a bizarre twist. The Asatru Folk Assembly, a group of worshippers of the Norse Gods Thor and Odin, filed an independent legal claim that Kennewick Man was actually a Viking. This Nordic sect, whose case you may read in your copy of The Runestone, were actually allowed to hold a religious service over the bones. This upset the Yakama Indian community, whose spokesman feared that the Viking ceremony could be "keeping Kennewick Man’s spirit from finding his body." The dispute between Indians and Norsemen might be settled by DNA comparison with Kennewick Man, and the Norsemen are quite keen to be put to this test. More probably, DNA would decide the case in favour of neither side. Further scientific study would certainly cast fascinating light on the question of when humans first arrived in America. But Indian leaders resent the very idea of studying this question, because they believe their ancestors have been in America since the creation. As Armanad Minthorn, religious leader of the Umatilla tribe, puts it: " From our oral histories, we know that our people have been part of this land since the beginning of time. We do not believe our people migrated here from another continent, as the scientists do."

Perhaps the best policy for the archaeologists would be to declare themselves a religion, with DNA fingerprints their sacramental totem. Facetious, but, such is the climate in the United States at the end of the 20th century, it is possibly the only recourse that would work. If you say, "Look, here is overwhelming evidence from carbon dating, from mitochondrial DNA, and from archaeological analyses of pottery, that X is the case" you will get nowhere. But if you say, "It is a fundamental and unquestioned belief of my culture that X is the case" you will immediately hold a judge’s attention.

Also the attention of many in the academic community who, in the late twentieth century, have discovered a new form of anti-scientific rhetoric, sometimes called the ‘postmodern critique’ of science. The most thorough whistle-blowing on this kind of thing is Paul Gross and Norman Levitt’s splendid book, Higher Superstition: The Academic Left and its Quarrels with Science. The American anthropologist Matt Cartmill sums up the basic credo:

"Anybody who claims to have objective knowledge about anything is trying to control and dominate the rest of us. . . There are no objective facts. All supposed "facts" are contaminated with theories, and all theories are infested with moral and political doctrines. . . Therefore, when some guy in a lab coat tells you that such and such is an objective fact . . . he must have a political agenda up his starched white sleeve."

There are even a few, but very vocal, fifth columnists within science itself who hold exactly these views, and use them to waste the time of the rest of us.

Cartmill’s thesis is that there is an unexpected and pernicious alliance between the know-nothing fundamentalist religious right, and the sophisticated academic left. A bizarre manifestation of the alliance is joint opposition to the theory of evolution. The opposition of the fundamentalists is obvious. That of the left is a compound of hostility to science in general, of ‘respect’ for tribal creation myths, and various political agendas. Both these strange bedfellows share a concern for ‘human dignity’ and take offence at treating humans as ‘animals’. Moreover, in Cartmill’s words,

Both camps believe that the big truths about the world are moral truths. They view the universe in terms of good and evil, not truth and falsehood. The first question they ask about any supposed fact is whether it serves the cause of righteousness."

And there is a feminist angle, which saddens me, for I am sympathetic to true feminism.

"Instead of exhorting young women to prepare for a variety of technical subjects by studying science, logic, and mathematics, Women’s Studies students are now being taught that logic is a tool of domination. . . the standard norms and methods of scientific inquiry are sexist because they are incompatible with "women’s ways of knowing." The authors of the prize-winning book with this title report that the majority of the women they interviewed fell into the category of ‘subjective knowers’, characterized by a ‘passionate rejection of science and scientists.’ These ‘subjectivist’ women see the methods of logic, analysis and abstraction as ‘alien territory belonging to men’ and ‘value intuition as a safer and more fruitful approach to truth’."

That was a quotation from the historian and philosopher of science Noretta Koertge, who is understandably worried about a subversion of feminism which could have a malign influence upon women’s education. Indeed, there is an ugly, hectoring streak in this kind of thinking. Barbara Ehrenreich and Janet McIntosh witnessed a woman psychologist speaking at an interdisciplinary conference. Various members of the audience attacked her use of the

. . . oppressive, sexist, imperialist, and capitalist scientific method. The psychologist tried to defend science by pointing to its great discoveries – for example, DNA. The retort came back: "You believe in DNA?"

Fortunately, there are still many intelligent young women prepared to enter a scientific career, and I should like to pay tribute to their courage in the face of such bullying intimidation.

I have come so far with scarcely a mention of Charles Darwin. His life spanned most of the nineteenth century, and he died with every right to be satisfied that he had cured humanity of its greatest and grandest illusion. Darwin brought life itself within the pale of the explicable. No longer a baffling mystery demanding supernatural explanation, life, with the complexity and elegance that defines it, grows and gradually emerges, by easily understood rules, from simple beginnings. Darwin’s legacy to the twentieth century was to demystify the greatest mystery of all.

Would Darwin be pleased with our stewardship of that legacy, and with what we are now in a position to pass to the twenty first century? I think he would feel an odd mixture of exhilaration and exasperation. Exhilaration at the detailed knowledge, the comprehensiveness of understanding, that science can now offer, and the polish with which his own theory is being brought to fulfilment. Exasperation at the ignorant suspicion of science, and the air-headed superstition, that still persist.

Exasperation is too weak a word. Darwin might justifiably be saddened, given our huge advantages over himself and his contemporaries, at how little we seem to have done to deploy our superior knowledge in our culture. Late twentieth century civilisation, Darwin would be dismayed to note, though imbued and surrounded by the products and advantages of science, has yet to draw science into its sensibility. Is there even a sense in which we have slipped backwards since Darwin’s co-discoverer, Alfred Russel Wallace wrote The Wonderful Century, a glowing scientific retrospective on his era?

Perhaps there was undue complacency in turn-of-century science, about how much had been achieved and how little more advancement could be expected. William Thomson, First Lord Kelvin, President of the Royal Society, pioneered the transatlantic cable – symbol of Victorian progress – and also the second law of thermodynamics – C P Snow’s litmus of scientific literacy. Kelvin is credited with the following three confident predictions: ‘Radio has no future.’ ‘Heavier than air flying machines are impossible.’ ‘X-rays will prove to be a hoax.’

Kelvin also gave Darwin a lot of grief by ‘proving,’ using all the prestige of the senior science of physics, that the sun was too young to have allowed time for evolution. Kelvin, in effect, said, "Physics argues against evolution, so your biology must be wrong." Darwin could have retorted: "Biology shows that evolution is a fact, so your physics must be wrong." Instead, he bowed to the prevailing assumption that physics automatically trumps biology, and fretted. Twentieth century physics, of course, showed Kelvin wrong by powers of ten. But Darwin did not live to see his vindication, and he never had the confidence to tell the senior physicist of his day where to get off.

In my attacks on millenarial superstition, I must beware of Kelvinian over-confidence. Undoubtedly there is much that we still don't know. Part of our legacy to the 21st century must be unanswered questions, and some of them are big ones. The science of any age must prepare to be superseded. It would be arrogant and rash to claim our present knowledge as all there is to know. Today's commonplaces, such as mobile telephones, would have seemed to previous ages pure magic. And that should be our warning. Arthur C. Clarke, distinguished novelist and evangelist for the limitless power of science, has said, 'Any sufficiently advanced technology is indistinguishable from magic.' This is Clarke's Third Law.

Maybe, some day in the future, physicists will fully understand gravity, and build an anti-gravity machine. Levitating people may one day become as commonplace to our descendants as jet planes are to us. So, if someone claims to have witnessed a magic carpet zooming over the minarets, should we believe him, on the grounds that those of our ancestors who doubted the possibility of radio turned out to be wrong? No, of course not. But why not?

Clarke's Third Law doesn't work in reverse. Given that 'Any sufficiently advanced technology is indistinguishable from magic' it does not follow that 'Any magical claim that anybody may make at any time is indistinguishable from a technological advance that will come some time in the future.'

Yes, there been occasions when authoritative sceptics have come away with egg on their pontificating faces. But a far greater number of magical claims have been made and never vindicated. A few things that would surprise us today will come true in the future. But lots and lots of things will not come true in the future. History suggests that the very surprising things that do come true are in a minority. The trick is to sort them out from the rubbish – from claims that will forever remain in the realm of fiction and magic.

It is right that, at the end of our century, we should show the humility that Kelvin, at the end of his, did not. But it is also right to acknowledge all that we have learned during the past hundred years. The digital century was the best I could come up with, as a single theme. But it covers only a fraction of what 20th century science will bequeath. We now know, as Darwin and Kelvin did not, how old the world is. About 4.6 billion years. We understand – what Alfred Wegener was ridiculed for suggesting – that the shape of geography has not always been the same. South America not only looks as if it might jigsaw neatly under the bulge of Africa. It once did exactly that, until they split apart some 125 million years ago. Madagascar once touched Africa on one side and India on the other. That was before India set off across the widening ocean and crashed into China to raise the Himalayas. The map of the world's continents has a time dimension, and we who are privileged to live in the Plate Tectonic Age know exactly how it haschanged, when, and why.

We know roughly how old the universe is, and, indeed, that it has an age, which is the same as the age of time itself, and less than twenty billion years. Having begun as a singularity with huge mass and temperature and very small volume, the universe has been expanding ever since. The 21st century will probably settle the question whether the expansion is to go on for ever, or go into reverse. The matter in the cosmos is not homogeneous, but is gathered into some hundred billion galaxies, each averaging a hundred billion stars. We can read the composition of any star in some detail, by spreading its light in a glorified rainbow. Among the stars, our sun is generally unremarkable. It is unremarkable, too, in having planets in orbit, as we know from detecting tiny rhythmic shifts in the spectrums of stars. There is no direct evidence that any other planets house life. If they do, such inhabited islands may be so scattered as to make it unlikely that one will ever encounter another.

We know in some detail the principles governing the evolution of our own island of life. It is a fair bet that the most fundamental principle – Darwinian natural selection – underlies, in some form, other islands of life, if any there be. We know that our kind of life is built of cells, where a cell is either a bacterium or a colony of bacteria. The detailed mechanics of our kind of life depend upon the near-infinite variety of shapes assumed by a special class of molecules called proteins. We know that those all-important three-dimensional shapes are exactly specified by a one-dimensional code, the genetic code, carried by DNA molecules which are replicated through geological time. We understand why there are so many different species, although we don't know how many. We cannot predict in detail how evolution will go in the future, but we can predict the general patterns that are to be expected.

Among the unsolved problems we shall bequeath to our successors, physicists such as Steven Weinberg will point to their Dreams of a Final Theory, otherwise known as the Grand Universal Theory, or Theory of Everything. Theorists differ about whether it will ever be attained. Those who think it will would probably date this scientific epiphany somewhere in the 21st century. Physicists famously resort to religious language when discussing such deep matters. Some of them really mean it. The others are at risk of being taken literally, when really they intend no more than I do when I say "God knows" to mean that I don't.

Biologists will reach their grail of writing down the human genome, early in the next century. They will then discover that it is not so final as some once hoped. The human embryo project – working out how the genes interact with their environments, including each other, to build a body – may take at least as long to complete. But it too will probably be finished during the 21st century, and artificial wombs built, if these should be thought desirable.

I am less confident about what is for me, as for most biologists, the outstanding scientific problem that remains: the question of how the human brain works, especially the nature of subjective consciousness. The last decade of this century has seen a flurry of big guns take aim at it, including Francis Crick no less, and Daniel Dennett, Steven Pinker and Sir Roger Penrose. It is a big, profound problem, worthy of minds like these. Obviously I have no solution. If I had, I'd deserve a Nobel Prize. It isn't even clear what kind of a problem it is, and therefore what kind of a brilliant idea would constitute a solution. Some people think the problem of consciousness an illusion: there's nobody home, and no problem to be solved. But before Darwin solved the riddle of life's provenance, in the last century, I don't think anybody had clearly posed what sort of a problem it was. It was only after Darwin had solved it that most people realised what it had been in the first place. I do not know whether consciousness will prove to be a big problem, solved by a genius; or will fritter unsatisfactorily away into a series of small problems and non problems.

I am by no means confident that the 21st century will solve the human mind. But if it does, there may be an additional byproduct. Our successors may then be in a position to understand the paradox of 20th century science:- On the one hand our century arguably added as much new knowledge to the human store as all previous centuries put together; while on the other hand the 20th century ended with approximately the same level of supernatural credulity as the 19th, and rather more outright hostility to science. With hope, if not with confidence, I look forward to the 21st century and what it may teach us.

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Science, Delusion and the Appetite for Wonder

The following is the Richard Dimbleby Lecture given for BBC1 Television on November 12th, 1996.
by Richard Dawkins

You could give Aristotle a tutorial. And you could thrill him to the core of his being. Aristotle was an encyclopedic polymath, an all time intellect. Yet not only can you know more than him about the world. You also can have a deeper understanding of how everything works. Such is the privilege of living after Newton, Darwin, Einstein, Planck, Watson, Crick and their colleagues.

I'm not saying you're more intelligent than Aristotle, or wiser. For all I know, Aristotle's the cleverest person who ever lived. That's not the point. The point is only that science is cumulative, and we live later.

Aristotle had a lot to say about astronomy, biology and physics. But his views sound weirdly naive today. Not as soon as we move away from science, however. Aristotle could walk straight into a modern seminar on ethics, theology, political or moral philosophy, and contribute. But let him walk into a modern science class and he'd be a lost soul. Not because of the jargon, but because science advances, cumulatively.

Here's a small sample of the things you could tell Aristotle, or any other Greek philosopher. And surprise and enthral them, not just with the facts themselves but with how they hang together so elegantly.

The earth is not the centre of the universe. It orbits the sun -- which is just another star. There is no music of the spheres, but the chemical elements, from which all matter is made, arrange themselves cyclically, in something like octaves. There are not four elements but about 100. Earth, air, fire and water are not among them.

Living species are not isolated types with unchanging essences. Instead, over a time scale too long for humans to imagine, they split and diverge into new species, which then go on diverging further and further. For the first half of geological time our ancestors were bacteria. Most creatures still are bacteria, and each one of our trillions of cells is a colony of bacteria. Aristotle was a distant cousin to a squid, a closer cousin to a monkey, a closer cousin still to an ape (strictly speaking, Aristotle was an ape, an African ape, a closer cousin to a chimpanzee than a chimp is to an orangutan).

The brain is not for cooling the blood. It's what you use to do your logic and your metaphysics. It's a three dimensional maze of a million million nerve cells, each one drawn out like a wire to carry pulsed messages. If you laid all your brain cells end to end, they'd stretch round the world 25 times. There are about 4 million million connections in the tiny brain of a chaffinch, proportionately more in ours.

Now, if you're anything like me, you'll have mixed feelings about that recitation. On the one hand, pride in what Aristotle's species now knows and didn't then. On the other hand an uneasy feeling of, "Isn't it all a bit complacent? What about our descendants, what will they be able to tell us?"

Yes, for sure, the process of accumulation doesn't stop with us. 2,000 years hence, ordinary people who have read a couple of books will be in a position to give a tutorial to today's Aristotles: to Francis Crick, say, or Stephen Hawking. So does this mean that our view of the universe will turn out to be just as wrong?

Let's keep a sense of proportion about this! Yes, there's much that we still don't know. But surely our belief that the earth is round and not flat, and that it orbits the sun, will never be superseded. That alone is enough to confound those, endowed with a little philosophical learning, who deny the very possibility of objective truth: those so-called relativists who see no reason to prefer scientific views over aboriginal myths about the world.

Our belief that we share ancestors with chimpanzees, and more distant ancestors with monkeys, will never be superseded although details of timing may change. Many of our ideas, on the other hand, are still best seen as theories or models whose predictions, so far, have survived the test. Physicists disagree over whether they are condemned forever to dig for deeper mysteries, or whether physics itself will come to an end in a final 'theory of everything', a nirvana of knowledge. Meanwhile, there is so much that we don't yet understand, we should loudly proclaim those things that we do, so as to focus attention on problems that we should be working on.

Far from being over-confident, many scientists believe that science advances only by disproof of its hypotheses. Konrad Lorenz said he hoped to disprove at least one of his own hypotheses every day before breakfast. That was absurd, especially coming from the grand old man of the science of ethology, but it is true that scientists, more than others, impress their peers by admitting their mistakes.

A formative influence on my undergraduate self was the response of a respected elder statesmen of the Oxford Zoology Department when an American visitor had just publicly disproved his favourite theory. The old man strode to the front of the lecture hall, shook the American warmly by the hand and declared in ringing, emotional tones: "My dear fellow, I wish to thank you. I have been wrong these fifteen years." And we clapped our hands red. Can you imagine a Government Minister being cheered in the House of Commons for a similar admission? "Resign, Resign" is a much more likely response!

Yet there is hostility towards science. And not just from the green ink underlining brigade, but from published novelists and newspaper columnists. Newspaper columns are notoriously ephemeral, but their drip drip, week after week, or day after day, repetition gives them influence and power, and we have to notice them. A peculiar feature of the British press is the regularity with which some of its leading columnists return to attack science -- and not always from a vantage point of knowledge. A few weeks ago, Bernard Levin's effusion in The Times was entitled "God, me and Dr Dawkins" and it had the subtitle: "Scientists don't know and nor do I -- but at least I know I don't know".

It is no mean task to plumb the full depths of what Mr Bernard Levin does not know, but here's an illustration of the gusto with which he boasts of it.

"Despite their access to copious research funds, today's scientists have yet to prove that a quark is worth a bag of beans. The quarks are coming! The quarks are coming! Run for your lives . . .! Yes, I know I shouldn't jeer at science, noble science, which, after all, gave us mobile telephones, collapsible umbrellas and multi-striped toothpaste, but science really does ask for it . . . Now I must be serious. Can you eat quarks? Can you spread them on your bed when the cold weather comes?"

It doesn't deserve a reply, but the distinguished Cambridge scientist, Sir Alan Cottrell, wrote a brief Letter to the Editor:- "Sir: Mr Bernard Levin asks 'Can you eat quarks?' I estimate that he eats 500,000,000,000,000, 000,000 quarks a day."
It has become almost a cliché to remark that nobody boasts of ignorance of literature, but it is socially acceptable to boast ignorance of science and proudly claim incompetence in mathematics. In Britain, that is. I believe the same is not true of our more successful economic competitors, Germany, the United States and Japan.

People certainly blame science for nuclear weapons and similar horrors. It's been said before but needs to be said again: if you want to do evil, science provides the most powerful weapons to do evil; but equally, if you want to do good, science puts into your hands the most powerful tools to do so. The trick is to want the right things, then science will provide you with the most effective methods of achieving them.

An equally common accusation is that science goes beyond its remit. It's accused of a grasping take-over bid for territory that properly belongs to other disciplines such as theology. On the other hand -- you can't win! -- listen to the novelist Fay Weldon's hymn of hate against 'the scientists' in The Daily Telegraph.

"Don't expect us to like you. You promised us too much and failed to deliver. You never even tried to answer the questions we all asked when we were six. Where did Aunt Maud go when she died? Where was she before she was born? . . . And who cares about half a second after the Big Bang; what about half a second before? And what about crop circles?"

More than some of my colleagues, I am perfectly happy to give a simple and direct answer to both those Aunt Maud questions. But I'd certainly be called arrogant and presumptuous, going beyond the limits of science.

Then there's the view that science is dull and plodding, with rows of biros in its top pocket. Here's another newspaper columnist, A A Gill, writing on science this year in The Sunday Times.

"Science is constrained by experiment results and the tedious, plodding stepping stones of empiricism . . . What appears on television just is more exciting than what goes on in the back of it . . . That's art, luvvie: theatre, magic, fairy dust, imagination, lights, music, applause, my public. There are stars and there are stars, darling. Some are dull, repetitive squiggles on paper, and some are fabulous, witty, thought-provoking, incredibly popular . . ."

The 'dull, repetitive squiggles' is a reference to the discovery of pulsars in 1967, by Jocelyn Bell and Anthony Hewish. Jocelyn Bell Burnell had recounted on television the spine-tingling moment when, a young woman on the threshold of a career, she first knew she was in the presence of something hitherto unheard-of in the universe. Not something new under the sun, a whole new KIND of sun, which rotates, so fast that, instead of taking 24 hours like our planet, it takes a quarter of a second. Darling, how too plodding, how madly empirical my dear!

Could science just be too difficult for some people, and therefore seem threatening? Oddly enough, I wouldn't dare to make such a suggestion, but I am happy to quote a distinguished literary scholar, John Carey, the present Merton Professor of English at Oxford:

"The annual hordes competing for places on arts courses in British universities, and the trickle of science applicants, testify to the abandonment of science among the young. Though most academics are wary of saying it straight out, the general consensus seems to be that arts courses are popular because they are easier, and that most arts students would simply not be up to the intellectual demands of a science course."
My own view is that the sciences can be intellectually demanding, but so can classics, so can history, so can philosophy. On the other hand, nobody should have trouble understanding things like the circulation of the blood and the heart's role in pumping it round. Carey quoted Donne's lines to a class of 30 undergraduates in their final year reading English at Oxford:

"Knows't thou how blood, which to the heart doth flow, Doth from one ventricle to the other go?"
Carey asked them how, as a matter of fact, the blood does flow. None of the thirty could answer, and one tentatively guessed that it might be 'by osmosis'. The truth -- that the blood is pumped from ventricle to ventricle through at least 50 miles of intricately dissected capillary vessels throughout the body -- should fascinate any true literary scholar. And unlike, say, quantum theory or relativity, it isn't hard to understand. So I tender a more charitable view than Professor Carey. I wonder whether some of these young people might have been positively turned off science.
Last month I had a letter from a television viewer who poignantly began: "I am a clarinet teacher whose only memory of science at school was a long period of studying the Bunsen burner." Now, you can enjoy the Mozart concerto without being able to play the clarinet. You can be a discerning and informed concert critic without being able to play a note. Of course music would come to a halt if nobody learned to play it. But if everybody left school thinking you had to play an intrument before you could appreciate music, think how impoverished many lives would be.

Couldn't we treat science in the same way? Yes, we must have Bunsen burners and dissecting needles for those drawn to advanced scientific practice. But perhaps the rest if us could have separate classes in science appreciation, the wonder of science, scientific ways of thinking, and the history of scientific ideas, rather than laboratory experience.

It's here that I'd seek rapprochement with another apparent foe of science, Simon Jenkins, former editor of The Times and a much more formidable adversary than the other journalists I've quoted, because he has some knowledge of what he is talking about. He resents compulsory science education and he holds the idiosyncratic view that it isn't useful. But he is thoroughly sound on the uplifting qualities of science. In a recorded conversation with me, he said:

"I can think of very few science books I've read that I've called useful. What they've been is wonderful. They've actually made me feel that the world around me is a much fuller . . . much more awesome place than I ever realised it was . . . I think that science has got a wonderful story to tell. But it isn't useful. It's not useful like a course in business studies or law is useful, or even a course in politics and economics."
Far from science not being useful, my worry is that it is so useful as to overshadow and distract from its

inspirational and cultural value. Usually even its sternest critics concede the usefulness of science, while completely missing the wonder. Science is often said to undermine our humanity, or destroy the mystery on which poetry is thought to thrive. Keats berated Newton for destroying the poetry of the rainbow.

"Philosophy will clip an Angel's wings, Conquer all mysteries by rule and line, Empty the haunted air, and gnomed mine -- Unweave a rainbow . . ."

Keats was, of course, a very young man.

Blake, too, lamented:

"For Bacon and Newton, sheath'd in dismal steel, their terrors hang Like iron scourges over Albion; Reasonings like vast Serpents Infold around my limbs . . ."

I wish I could meet Keats or Blake to persuade them that mysteries don't lose their poetry because they are solved. Quite the contrary. The solution often turns out more beautiful than the puzzle, and anyway the solution uncovers deeper mystery. The rainbow's dissection into light of different wavelengths leads on to Maxwell's equations, and eventually to special relativity.

Einstein himself was openly ruled by an aesthetic scientific muse: "The most beautiful thing we can experience is the mysterious. It is the source of all true art and science", he said. It's hard to find a modern particle physicist who doesn't own to some such aesthetic motivation. Typical is John Wheeler, one of the distinguished elder statesmen of American physics today:

" . . . we will grasp the central idea of it all as so simple, so beautiful, so compelling that we will all say each to the other, 'Oh, how could it have been otherwise! How could we all have been so blind for so long!'"
Wordsworth might have understood this better than his fellow romantics. He looked forward to a time when scientific discoveries would become "proper objects of the poet's art". And, at the painter Benjamin Haydon's dinner of 1817, he endeared himself to scientists, and endured the taunts of Keats and Charles Lamb, by refusing to join in their toast: "Confusion to mathematics and Newton".

Now, here's an apparent confusion: T H Huxley saw science as "nothing but trained and organized common sense", while Professor Lewis Wolpert insists that it's deeply paradoxical and surprising, an affront to commonsense rather than an extension of it. Every time you drink a glass of water, you are probably imbibing at least one atom that passed through the bladder of Aristotle. A tantalisingly surprising result, but it follows by Huxley-style organized common sense from Wolpert's observation that "there are many more molecules in a glass of water than there are glasses of water in the sea".

Science runs the gamut from the tantalisingly surprising to the deeply strange, and ideas don't come any stranger than Quantum Mechanics. More than one physicist has said something like: "If you think you understand quantum theory, you don't understand quantum theory."
There is mystery in the universe, beguiling mystery, but it isn't capricious, whimsical, frivolous in its changeability. The universe is an orderly place and, at a deep level, regions of it behave like other regions, times behave like other times. If you put a brick on a table it stays there unless something lawfully moves it, even if you meanwhile forget it's there. Poltergeists and sprites don't intervene and hurl it about for reasons of mischief or caprice. There is mystery but not magic, strangeness beyond the wildest imagining, but no spells or witchery, no arbitrary miracles.

Even science fiction, though it may tinker with the laws of nature, can't abolish lawfulness itself and remain good science fiction. Young women don't take off their clothes and spontaneously morph themselves into wolves. A recent television drama is fairytale rather than science fiction, for this reason. It falls foul of a theoretical prohibition much deeper than the philosopher's "All swans are white -- until a black one turns up" inductive reasoning. We know people can't metamorphose into wolves, not because the phenomenon has never been observed -- plenty of things happen for the first time -- but because werewolves would violate the equivalent of the second law of thermodynamics. Of this, Sir Arthur Eddington said:

"If someone points out to you that your pet theory of the universe is in disagreement with Maxwell's equations

- then so much the worse for Maxwell's equations. If it is found to be contradicted by observation - well, these experimentalists do bungle things sometimes. But if your theory is found to be against the second law of thermodynamics I can give you no hope; there is nothing for it but to collapse in deepest humiliation."

To pursue the relationship between werewolves and entropy would take me too far afield. But, since this lecture commemorates a man whose integrity and honesty as a broadcaster is still an abiding legend 30 years after his death, I'll stay for a moment with the current epidemic of paranormal propaganda on television.

In one popular type of programming, conjurers come on and do routine tricks. But instead of admitting that they are conjurers, these television performers claim genuinely supernatural powers. In this they are abetted by prestigious, even knighted, presenters, people whom we have got into the habit of trusting, broadcasters who have become role models. It is an abuse of what might be called the Richard Dimbleby Effect.

In other programmes, disturbed people recount their fantasies of ghosts and poltergeists. But instead of sending them off to a kindly psychiatrist, television producers eagerly hire actors to re-create their delusions - with predictable effects on the credulity of large audiences.

Recently, a faith healer was given half an hour of free prime time television, to advertise his bizarre claim to be a 2000 year-dead physician called Paul of Judea. Some might call this entertainment, comedy even, though others would find it objectionable entertainment, like a fairground freak show.

Now I obviously have to return to the arrogance problem. How can I be so sure that this ordinary Englishman with an unlikely foreign accent was not the long dead Paul of Judea? How do I know that astrology doesn't work? How can I be so confident that the television 'supernaturalists' are ordinary conjurers, just because ordinary conjurers can replicate their tricks? (spoonbending, by the way, is so routine a trick that the American conjurers Penn and Teller have posted instructions for doing it on the Internet!
It really comes down to parsimony, economy of explanation. It is possible that your car engine is driven by psychokinetic energy, but if it looks like a petrol engine, smells like a petrol engine and performs exactly as well as a petrol engine, the sensible working hypothesis is that it is a petrol engine. Telepathy and possession by the spirits of the dead are not ruled out as a matter of principle. There is certainly nothing impossible about abduction by aliens in UFOs. One day it may be happen. But on grounds of probability it should be kept as an explanation of last resort. It is unparsimonious, demanding more than routinely weak evidence before we should believe it. If you hear hooves clip-clopping down a London street, it could be a zebra or even a unicorn, but, before we assume that it's anything other than a horse, we should demand a certain minimal standard of evidence.

It's been suggested that if the supernaturalists really had the powers they claim, they'd win the lottery every week. I prefer to point out that they could also win a Nobel Prize for discovering fundamental physical forces hitherto unknown to science. Either way, why are they wasting their talents doing party turns on television?

By all means let's be open-minded, but not so open-minded that our brains drop out. I'm not asking for all such programmes to be suppressed, merely that the audience should be encouraged to be critical. In the case of the psychokineticists and thought-readers, it would be good entertainment to invite studio audiences to suggest critical tests, which only genuine psychics, but not ordinary conjurers, could pass. It would make a good, entertaining form of quiz show.
How do we account for the current paranormal vogue in the popular media? Perhaps it has something to do with the millennium -- in which case it's depressing to realise that the millennium is still three years away. Less portentously, it may be an attempt to cash in on the success of The X-Files. This is fiction and therefore defensible as pure entertainment.

A fair defence, you might think. But soap operas, cop series and the like are justly criticised if, week after week, they ram home the same prejudice or bias. Each week The X-Files poses a mystery and offers two rival kinds of explanation, the rational theory and the paranormal theory. And, week after week, the rational explanation loses. But it is only fiction, a bit of fun, why get so hot under the collar?

Imagine a crime series in which, every week, there is a white suspect and a black suspect. And every week, lo and behold, the black one turns out to have done it. Unpardonable, of course. And my point is that you could not defend it by saying: "But it's only fiction, only entertainment".

Let's not go back to a dark age of superstition and unreason, a world in which every time you lose your keys you suspect poltergeists, demons or alien abduction.
Enough, let me turn to happier matters. The popularity of the paranormal, oddly enough, might even be grounds for encouragement. I think that the appetite for mystery, the enthusiasm for that which we do not understand, is healthy and to be fostered. It is the same appetite which drives the best of true science, and it is an appetite which true science is best qualified to satisfy. Perhaps it is this appetite that underlies the ratings success of the paranormalists.

I believe that astrologers, for instance, are playing on -- misusing, abusing -- our sense of wonder. I mean when they hijack the constellations, and employ sub-poetic language like the moon moving into the fifth house of Aquarius. Real astronomy is the rightful proprietor of the stars and their wonder. Astrology gets in the way, even subverts and debauches the wonder.

To show how real astronomical wonder can be presented to children, I'll borrow from a book called "Earthsearch" by John Cassidy, which I brought back from America to show my daughter Juliet. Find a large open space and take a soccer ball to represent the sun. Put the ball down and walk ten paces in a straight line. Stick a pin in the ground. The head of the pin stands for the planet Mercury. Take another 9 paces beyond Mercury and put down a peppercorn to represent Venus. Seven paces on, drop another peppercorn for Earth. One inch away from earth, another pinhead represents the Moon, the furthest place, remember, that we've so far reached. 14 more paces to little Mars, then 95 paces to giant Jupiter, a ping-pong ball. 112 paces further, Saturn is a marble. No time to deal with the outer planets except to say that the distances are much larger. But, how far would you have to walk to reach the nearest star, Proxima Centauri? Pick up another soccer ball to represent it, and set off for a walk of 4200 miles. As for the nearest other galaxy, Andromeda, don't even think about it!

Who'd go back to astrology when they've sampled the real thing -- astronomy, Yeats's "starry ways", his "lonely, majestical multitude"? The same lovely poem encourages us to "Remember the wisdom out of the old days" and I want to end with a little piece of wonder from my own territory of evolution.

You contain a trillion copies of a large, textual document written in a highly accurate, digital code, each copy as voluminous as a substantial book. I'm talking, of course, of the DNA in your cells. Textbooks describe DNA as a blueprint for a body. It's better seen as a recipe for making a body, because it is irreversible. But today I want to present it as something different again, and even more intriguing. The DNA in you is a coded description of ancient worlds in which your ancestors lived. DNA is the wisdom out of the old days, and I mean very old days indeed.

The oldest human documents go back a few thousand years, originally written in pictures. Alphabets seem to have been invented about 35 centuries ago in the Middle East, and they've changed and spawned numerous varieties of alphabet since then. The DNA alphabet arose at least 35 million centuries ago. Since that time, it hasn't changed one jot. Not just the alphabet, the dictionary of 64 basic words and their meanings is the same in modern bacteria and in us. Yet the common ancestor from whom we both inherited this precise and accurate dictionary lived at least 35 million centuries ago.

What changes is the long programs that natural selection has written using those 64 basic words. The messages that have come down to us are the ones that have survived millions, in some cases hundreds of millions, of generations. For every successful message that has reached the present, countless failures have fallen away like the chippings on a sculptor's floor. That's what Darwinian natural selection means. We are the descendants of a tiny élite of successful ancestors. Our DNA has proved itself successful, because it is here. Geological time has carved and sculpted our DNA to survive down to the present.

There are perhaps 30 million distinct species in the world today. So, there are 30 million distinct ways of making a living, ways of working to pass DNA on to the future. Some do it in the sea, some on land. Some up trees, some underground. Some are plants, using solar panels - we call them leaves - to trap energy. Some eat the plants. Some eat the herbivores. Some are big carnivores that eat the small ones. Some live as parasites inside other bodies. Some live in hot springs. One species of small worms is said to live entirely inside German beer mats. All these different ways of making a living are just different tactics for passing on DNA. The differences are in the details.
The DNA of a camel was once in the sea, but it hasn't been there for a good 300 million years. It has spent most of recent geological history in deserts, programming bodies to withstand dust and conserve water. Like

sandbluffs carved into fantastic shapes by the desert winds, camel DNA has been sculpted by survival in ancient deserts to yield modern camels.

At every stage of its geological apprenticeship, the DNA of a species has been honed and whittled, carved and rejigged by selection in a succession of environments. If only we could read the language, the DNA of tuna and starfish would have 'sea' written into the text. The DNA of moles and earthworms would spell 'underground'. Of course all the DNA would spell many other things as well. Shark and cheetah DNA would spell 'hunt', as well as separate messages about sea and land.

We can't read these messages yet. Maybe we never shall, for their language is indirect, as befits a recipe rather than a reversible blueprint. But it's still true that our DNA is a coded description of the worlds in which our ancestors survived. We are walking archives of the African Pliocene, even of Devonian seas, walking repositories of wisdom out of the old days. You could spend a lifetime reading such messages and die unsated by the wonder of it.

We are going to die, and that makes us the lucky ones. Most people are never going to die because they are never going to be born. The potential people who could have been standing in my place but who will never see the light of day outnumber the sand grains of Sahara -- more, the atoms in the universe. Certainly those unborn ghosts include greater poets than Donne, greater scientists than Newton, greater composers than Beethoven. We know this because the set of possible people allowed by our DNA so massively outnumbers the set of actual people. In the teeth of these stupefying odds it is you and I that are privileged to be here, privileged with eyes to see where we are and brains to wonder why.

There is an appetite for wonder, and isn't true science well qualified to feed it?

It's often said that people 'need' something more in their lives than just the material world. There is a gap that must be filled. People need to feel a sense of purpose. Well, not a BAD purpose would be to find out what is already here, in the material world, before concluding that you need something more. How much more do you want? Just study what is, and you'll find that it already is far more uplifting than anything you could imagine needing.

You don't have to be a scientist -- you don't have to play the bunsen burner -- in order to understand enough science to overtake your imagined need and fill that fancied gap. Science needs to be released from the lab into the culture.

Snake Oil and Holy Water

by Richard Dawkins
Article in FORBES ASAP October 4, 1999

Are science and religion converging? No.

There are modern scientists whose words sound religious but whose beliefs, on close examination, turn out to be identical to those of other scientists who call themselves atheists. Ursula Goodenough's lyrical book, The Sacred Depths of Nature, is sold as a religious book, is endorsed by theologians on the back cover, and its chapters are liberally laced with prayers and devotional meditations.

Yet, by the book's own account, Goodenough does not believe in any sort of supreme being, does not believe in any sort of life after death. By any normal understanding of the English language, she is no more religious than I am. She shares with other atheistic scientists a feeling of awe at the majesty of the universe and the intricate complexity of life. Indeed, the jacket copy for her book--the message that science does not "point to an existence that is bleak, devoid of meaning, pointless," but on the contrary "can be a wellspring of solace and hope"--would have been equally suitable for my book, Unweaving the Rainbow, or Carl Sagan's Pale Blue Dot. If that is religion, then I am a deeply religious man. But it isn't. And I'm not. As far as I can tell, my "atheistic" views are identical to Ursula's "religious" ones. One of us is misusing the English language, and I don't think it's me.

Goodenough happens to be a biologist, but this kind of neo-Deistic pseudoreligion is more often associated with physicists. In Stephen Hawking's case, I hasten to insist, the accusation is unjust. His much-quotd phrase, "the mind of God," no more indicates belief in God than my saying, "God knows!" as a way of indicating that I don't. I suspect the same of Einstein invoking "dear Lord" to personify the laws of physics. Paul Davies, however, adopted Hawking's phrase as the title of a book that went on to earn the Templeton Prize for Progress in Religion, the most lucrative prize in the world today, prestigious enough to be presented in Westminster Abbey. The philosopher Daniel Dennett once remarked to me in Faustian vein: "Richard, if ever you fall on hard times..."

If you count Einstein and Hawking as religious, if you allow the cosmic awe of Goodenough, Davies, Sagan, and me as true religion, then religion and science have indeed merged, especially when you factor in such atheistic priests as Don Cupitt and many university chaplains. But if the term religion is allowed such a flabbily elastic definition, what word is left for conventional religion, religion as the ordinary person in the pew or on the prayer mat understands it today--indeed, as any intellectual would have understood it in previous centuries, when intellectuals were religious like everybody else?

If God is a synonym for the deepest principles of physics, what word is left for a hypothetical being who answers prayers, intervenes to save cancer patients or helps evolution over difficult jumps, forgives sins or dies for them? If we are allowed to relabel scientific awe as a religious impulse, the case goes through on the nod. You have redefined science as religion, so it's hardly surprising if they turn out to "converge."

Another kind of marriage has been alleged between modern physics and Eastern mysticism. The argument goes as follows: Quantum mechanics, that brilliantly successful flagship theory of modern science, is deeply mysterious and hard to understand. Eastern mystics have always been deeply mysterious and hard to understand. Therefore, Eastern mystics must have been talking about quantum theory all along.

Similar mileage is made of Heisenberg's uncertainty principle ("Aren't we all, in a very real sense, uncertain?"), fuzzy logic ("Yes, it's okay for you to be fuzzy, too"), chaos and complexity theory (the butterfly effect, the Platonic, hidden beauty of the Mandelbrot Set--you name it, somebody has mysticized it and turned it into dollars). You can buy any number of books on "quantum healing," not to mention quantum psychology, quantum responsibility, quantum morality, quantum immortality, and quantum theology. I haven't found a book on quantum feminism, quantum financial management, or Afro-quantum theory, but give it time.

The whole dippy business is ably exposed by the physicist Victor Stenger in his book, The Unconscious Quantum, from which the following gem is taken. In a lecture on "Afrocentric healing," the psychiatrist Patricia Newton said that traditional healers "are able to tap that other realm of negative entropy--that superquantum velocity and frequency of electromagnetic energy--and bring them as conduits down to our level. It's not magic. It's not mumbo jumbo. You will see the dawn of the 21st century, the new medical quantum physics really distributing these energies and what they are doing."

Sorry, but mumbo jumbo is precisely what it is. Not African mumbo jumbo but pseudoscientific mumbo jumbo, down to the trademark misuse of the word energy. It is also religion, masquerading as science in a cloying love feast of bogus convergence.

n 1996 the Vatican, fresh from its magnanimous reconciliation with Galileo, a mere 350 years after his death, publicly announced that evolution had been promoted from tentative hypothesis to accepted theory of science. This is less dramatic than many American Protestants think it is, for the Roman Catholic Church has never been noted for biblical literalism--on the contrary, it has treated the Bible with suspicion, as something close to a subversive document, needing to be carefully filtered through priests rather than given raw to congregations. The pope's recent message on evolution has, nevertheless, been hailed as another example of late-20th-century convergence between science and religion.

Responses to the pope's message exhibited liberal intellectuals at their worst, falling over themselves in their eagerness to concede to religion its own magisterium, of equal importance to that of science, but not opposed to it. Such agnostic conciliation is, once again, easy to mistake for a genuine meeting of minds.

At its most naive, this appeasement policy partitions the intellectual territory into "how questions" (science) and "why questions" (religion). What are "why questions," and why should we feel entitled to think they deserve an answer? There may be some deep questions about the cosmos that are forever beyond science. The mistake is to think that they are therefore not beyond religion, too.

I once asked a distinguished astronomer, a fellow of my college, to explain the big bang theory to me. He did so to the best of his (and my) ability, and I then asked what it was about the fundamental laws of physics that made the spontaneous origin of space and time possible. "Ah," he smiled, "now we move beyond the realm of science. This is where I have to hand you over to our good friend, the chaplain." But why the chaplain? Why not the gardener or the chef? Of course chaplains, unlike chefs and gardeners, claim to have some insight into ultimate questions. But what reason have we ever been given for taking their claims seriously? Once again, I suspect that my friend, the professor of astronomy, was using the Einstein/Hawking trick of letting "God" stand for "That which we don't understand." It would be a harmless trick if it were not continually misunderstood by those hungry to misunderstand it. In any case, optimists among scientists, of whom I am one, will insist, "That which we don't understand" means only "That which we don't yet understand." Science is still working on the problem. We don't know where, or even whether, we ultimately shall be brought up short.

Agnostic conciliation, which is the decent liberal bending over backward to concede as much as possible to anybody who shouts loud enough, reaches ludicrous lengths in the following common piece of sloppy thinking. It goes roughly like this: You can't prove a negative (so far so good). Science has no way to disprove the existence of a supreme being (this is strictly true). Therefore, belief or disbelief in a supreme being is a matter of pure, individual inclination, and both are therefore equally deserving of respectful attention! When you say it like that, the fallacy is almost self-evident; we hardly need spell out the reductio ad absurdum. As my colleague, the physical chemist Peter Atkins, puts it, we must be equally agnostic about the theory that there is a teapot in orbit around the planet Pluto. We can't disprove it. But that doesn't mean the theory that there is a teapot is on level terms with the theory that there isn't.

Now, if it be retorted that there actually are reasons X, Y, and Z for finding a supreme being more plausible than a teapot, then X, Y, and Z should be spelled out--because, if legitimate, they are proper scientific arguments that should be evaluated. Don't protect them from scrutiny behind a screen of agnostic tolerance. If religious arguments are actually better than Atkins' teapot theory, let us hear the case. Otherwise, let those who call themselves agnostic with respect to religion add that they are equally agnostic about orbiting teapots. At the same time, modern theists might acknowledge that, when it comes to Baal and the golden calf, Thor and Wotan, Poseidon and Apollo, Mithras and Ammon Ra, they are actually atheists. We are all atheists about most of the gods that humanity has ever believed in. Some of us just go one god further.

In any case, the belief that religion and science occupy separate magisteria is dishonest. It founders on the undeniable fact that religions still make claims about the world that on analysis turn out to be scientific claims. Moreover, religious apologists try to have it both ways. When talking to intellectuals, they carefully keep off science's turf, safe inside the separate and invulnerable religious magisterium. But when talking to a nonintellectual mass audience, they make wanton use of miracle stories--which are blatant intrusions into scientific territory.

The Virgin Birth, the Resurrection, the raising of Lazarus, even the Old Testament miracles, all are freely used for religious propaganda, and they are very effective with an audience of unsophisticates and children. Every one of these miracles amounts to a violation of the normal running of the natural world. Theologians should make a choice. You can claim your own magisterium, separate from science's but still deserving of respect. But in that case, you must renounce miracles. Or you can keep your Lourdes and your miracles and enjoy their huge recruiting potential among the uneducated. But then you must kiss goodbye to separate magisteria and your high-minded aspiration to converge with science.

The desire to have it both ways is not surprising in a good propagandist. What is surprising is the readiness of liberal agnostics to go along with it, and their readiness to write off, as simplistic, insensitive extremists, those of us with the temerity to blow the whistle. The whistle-blowers are accused of imagining an outdated caricature of religion in which God has a long white beard and lives in a physical place called heaven. Nowadays, we are told, religion has moved on. Heaven is not a physical place, and God does not have a physical body where a beard might sit. Well, yes, admirable: separate magisteria, real convergence. But the doctrine of the Assumption was defined as an Article of Faith by Pope Pius XII as recently as November 1, 1950, and is binding on all Catholics. It clearly states that the body of Mary was taken into heaven and reunited with her soul. What can that mean, if not that heaven is a physical place containing bodies? To repeat, this is not a quaint and obsolete tradition with just a purely symbolic significance. It has officially, and recently, been declared to be literally true.

Convergence? Only when it suits. To an honest judge, the alleged marriage between religion and science is a shallow, empty, spin-doctored sham.

Written for the Freedom From Religion Foundation, Madison, Wisconsin, September 2001.

Distinguished British scientist, author and atheist Richard Dawkins, who was scheduled to accept an "Emperor Has No Clothes Award" on Sept. 22 at the Freedom From Religion Foundation convention, cancelled his appearance in light of travel difficulties after the Sept. 11 terrorist attacks against the United States.
He supplied an exclusive article, reprinted below, which was read at the Foundation convention in his stead by James Coors, a professor of Agronomy at the University of Wisconsin-Madison.
The essay is a follow-up to Dawkins' powerful article, "Religion's Misguided Missiles," appearing in The Guardian on September 15, 2001

Stop respecting religion and start submitting it to the same scutiny as any other idea or argument, says Richard Dawkins. And September 11th 2001 makes this scrutiny more urgent than ever...

"To blame Islam for what happened in New York is like blaming Christianity for the troubles in Northern Ireland!" Yes. Precisely. It is time to stop pussyfooting around. Time to get angry. And not only with Islam.

Those of us who have renounced one or other of the three 'great' monotheistic religions have, until now, moderated our language for reasons of politeness. Christians, Jews and Muslims are sincere in their beliefs and in what they find holy. We have respected that, even as we have disagreed with it. The late Douglas Adams put it with his customary good humour, in an impromptu speech in 1998 (slightly abridged):

Now, the invention of the scientific method is, I'm sure we'll all agree, the most powerful intellectual idea, the most powerful framework for thinking and investigating and understanding and challenging the world around us that there is, and it rests on the premise that any idea is there to be attacked. If it withstands the attack then it lives to fight another day and if it doesn't withstand the attack then down it goes. Religion doesn't seem to work like that. It has certain ideas at the heart of it which we call sacred or holy or whatever. What it means is, "Here is an idea or a notion that you're not allowed to say anything bad about; you're just not. Why not? — because you're not!" If somebody votes for a party that you don't agree with, you're free to argue about it as much as you like; everybody will have an argument but nobody feels aggrieved by it. If somebody thinks taxes should go up or down you are free to have an argument about it. But on the other hand if somebody says "I mustn't move a light switch on a Saturday," you say, "I respect that."

The odd thing is, even as I am saying that I am thinking "Is there an Orthodox Jew here who is going to be offended by the fact that I just said that?" But I wouldn't have thought, "Maybe there's somebody from the left wing or somebody from the right wing or somebody who subscribes to this view or the other in economics," when I was making the other points. I just think, "Fine, we have different opinions." But, the moment I say something that has something to do with somebody's (I'm going to stick my neck out here and say irrational) beliefs, then we all become terribly protective and terribly defensive and say "No, we don't attack that; that's an irrational belief but no, we respect it."

Why should it be that it's perfectly legitimate to support the Labour party or the Conservative party, Republicans or Democrats, this model of economics versus that, Macintosh instead of Windows — but to have an opinion about how the Universe began, about who created the Universe... no, that's holy? What does that mean? Why do we ring-fence that for any other reason other than that we've just got used to doing so? There's no other reason at all, it's just one of those things that crept into being, and once that loop gets going it's very, very powerful. So, we are used to not challenging religious ideas but it's very interesting how much of a furore Richard creates when he does it! Everybody gets absolutely frantic about it because you're not allowed to say these things. Yet when you look at it rationally there is no reason why those ideas shouldn't be as open to debate as any other, except that we have agreed somehow between us that they shouldn't be. (http://www.biota.org/people/douglasadams/index.html)

Douglas is dead, but his words are an inspiration to us now to stand up and break this absurd taboo. My last vestige of 'hands off religion' respect disappeared as I watched the "Day of Prayer" in Washington Cathedral. Then there was the even more nauseating prayer-meeting in the New York stadium, where prelates and pastors did their tremulous Martin Luther King impersonation and urged people of mutually incompatible faiths to hold hands in homage to the very force that caused the problem in the first place. It is time for people of intellect, as opposed to people of faith, to stand up and say, “Enough!” Let our tribute to the September dead be a new resolve: to respect people for what they individually think, rather than respect groups for what they were collectively brought up to believe.

Notwithstanding bitter sectarian hatreds over the centuries (all too obviously still going strong), Judaism, Islam and Christianity have much in common. Despite New Testament watering down and other reformist tendencies, all three pay historic allegiance to the same violent and vindictive God of Battles, memorably summed up by Gore Vidal in 1998:

The great unmentionable evil at the center of our culture is monotheism. From a barbaric Bronze Age text known as the Old Testament, three anti-human religions have evolved —Judaism, Christianity, and Islam. These are sky-god religions. They are, literally, patriarchal — God is the Omnipotent Father — hence the loathing of women for 2,000 years in those countries afflicted by the sky-god and his earthly male delegates. The sky-god is a jealous god, of course. He requires total obedience from everyone on earth, as he is not just in place for one tribe, but for all creation. Those who would reject him must be converted or killed for their own good.

In the Guardian of September 15th (http://www. guardian.co.uk/ Archive/0,423,4257777,00.html), I named belief in an afterlife as the key weapon that made the New York atrocity possible. Of prior significance is religion’s deep responsibility for the underlying hatreds that motivated people to use that weapon in the first place. To breathe such a suggestion, even with the most gentlemanly restraint, is to invite an onslaught of patronising abuse, as Douglas Adams noted. But the insane cruelty of the suicide attacks, and the equally vicious though numerically less catastrophic ‘revenge’ attacks on hapless Muslims living in America and Britain, push me beyond ordinary caution.

How can I say that religion is to blame? Do I really imagine that, when a terrorist kills, he is motivated by a theological disagreement with his victim? Do I really think the Northern Ireland pub bomber says to himself, “Take that, Tridentine Transubstantiationist bastards!” Of course I don’t think anything of the kind. Theology is the last thing on the minds of such people. They are not killing because of religion itself, but because of political grievances, often justified. They are killing because the other lot killed their fathers. Or because the other lot drove their great- grandfathers off their land. Or because the other lot oppressed our lot economically for centuries.

My point is not that religion itself is the motivation for wars, murders and terrorist attacks, but that religion is the principal label, and the most dangerous one, by which a ‘they’ as opposed to a ‘we’ can be identified at all. I am not even claiming that religion is the only label by which we identify the victims of our prejudice. There’s also skin colour, language, and social class. But often, as in Northern Ireland, these don’t apply and religion is the only divisive label around. Even when it is not alone, religion is nearly always an incendiary ingredient in the mix as well. And please don’t trot out Hitler as a counter-example. Hitler’s sub-Wagnerian ravings constituted a religion of his own foundation, and his anti-Semitism owed a lot to his never-renounced Roman Catholicism (see http://www.secularhumanism.org/library/fi/murphy_19 _2.html).

It is not an exaggeration to say that religion is the most inflammatory enemy-labelling device in history. Who killed your father? Not the individuals you are about to kill in ‘revenge’. The culprits themselves have vanished over the border. The people who stole your great-grandfather’s land have died of old age. You aim your vendetta at those who belong to the same religion as the original perpetrators. It wasn’t Seamus who killed your brother, but it was Catholics, so Seamus deserves to die ‘in return’. Next, it was Protestants who killed Seamus so let’s go out and kill some Protestants ‘in revenge’. It was Muslims who destroyed the World Trade Center so let’s set upon the turbaned driver of a London taxi and leave him paralysed from the neck down.

The bitter hatreds that now poison Middle Eastern politics are rooted in the real or perceived wrong of the setting up of a Jewish State in an Islamic region. In view of all that the Jews had been through, it must have seemed a fair and humane solution. Probably deep familiarity with the Old Testament had given the European and American decision-makers some sort of idea that this really was the “historic homeland” of the Jews (though the horrific stories of how Joshua and others conquered their Lebensraum might have made them wonder). Even if it wasn't justifiable at the time, no doubt a good case can be made that, since Israel exists now, to try to reverse the status quo would be a worse wrong.

I do not intend to get into that argument. But if it had not been for religion, the very concept of a Jewish State would have had no meaning in the first place. Nor would the very concept of Islamic lands, as something to be invaded and desecrated. In a world without religion, there would have been no Crusades; no Inquisition; no anti-Semitic pogroms (the people of the diaspora would long ago have intermarried and become indistinguishable from their host populations); no Northern Ireland Troubles (no label by which to distinguish the two 'communities', and no sectarian schools to teach the children historic hatreds — they would simply be one community.)

It is a spade we have here, let's call it a spade. The Emperor has no clothes. It is time to stop the mealy-mouthed euphemisms: 'Nationalists', 'Loyalists', 'Communities', 'Ethnic Groups', 'Cultures'. 'Civilisations'. Religions is the word you need. Religion is the word you are struggling hypocritically to avoid.

Parenthetically, religion is unusual among divisive labels in being spectacularly unnecessary. If religious beliefs had any evidence going for them, we might have to respect them in spite of their concomitant unpleasantness. But there is no such evidence. To label people as death-deserving enemies because of disagreements about real world politics is bad enough. To do the same for disagreements about a delusional world inhabited by archangels, demons and imaginary friends is ludicrously tragic.

The resilience of this form of hereditary delusion is as astonishing as its lack of realism. It seems that control of the plane which crashed near Pittsburgh was probably wrestled out of the hands of the terrorists by a group of brave passengers. The wife of one of these valiant and heroic men, after she took the telephone call in which he announced their intention, said that God had placed her husband on the plane as His instrument to prevent the plane crashing on the White House. I have the greatest sympathy for this poor woman in her tragic loss, but just think about it! As my (also understandably overwrought) American correspondent who sent me this piece of news said:

"Couldn't God have just given the hijackers a heart attack or something instead of killing all those nice people on the plane? I guess he didn't give a flying fuck about the Trade Center, didn't bother to come up with a plan for them" (I apologise for my friend's intemperate language but, in the circumstances, who can blame her?)

Is there no catastrophe terrible enough to shake the faith of people, on both sides, in God's goodness and power? No glimmering realisation that he might not be there at all: that we just might be on our own, needing to cope with the real world like grown-ups? Billy Graham, Mr Bush's spiritual advisor, said in Washington Cathedral:

But how do we understand something like this? Why does God allow evil like this to take place? Perhaps that is what you are asking now. You may even be angry at God. I want to assure you that God understands those feelings that you may have.

What an honour, to be licensed to speak for God! But even Billy Graham's patronising presumption now fails him:

I have been asked hundreds of times in my life why God allows tragedy and suffering. I have to confess that I really do not know the answer totally, even to my own satisfaction. I have to accept, by faith, that God is sovereign, and He is a God of love and mercy and compassion in the midst of suffering. The Bible says God is not the author of evil. It speaks of evil as a "mystery".

Less baffled by this deep theological mystery were two of America's best-known televangelists, Pat Robertson and Jerry Falwell. They knew exactly where to put the blame. Falwell said that God had protected America wonderfully for 225 years, but now, what with abortion and gays and lesbians and the ACLU, "all of them who have tried to secularise America... I point the finger in their face and say you helped this happen." "Well, I totally concur," responded Robertson. Bush, to his credit, swiftly disowned this revealing example of the religious mind at work.

The United States is the most religiose country in Christendom, and its born-again leader is eyeball to eyeball with the most religiose people on Earth (the Taliban's religion-inspired laws include draconian penalties for men whose beard is too short — Monty Python could not have dreamed it up.) Both sides believe that the Bronze-Age God of Battles is on their side. Both take risks with the world's future in unshakeable, fundamentalist faith that God will grant them the victory. J.C. Squire's famous verse on the First World War comes to mind:

God heard the nations sing and shout

"Gott strafe England" and "God save the King!"

God this, God that, and God the other thing —

"Good God!" said God, "I've got my work cut out!"

Incidentally, people speak of Islamic Fundamentalists, but the customary genteel distinction between fundamentalist and moderate Islam has been convincingly demolished by Ibn Warraq in his well-informed book, Why I am not a Muslim (see also his statement at the website for Secular Islam: http://www.secularislam.org/).

The human psyche has two great sicknesses: the urge to carry vendetta across generations, and the tendency to fasten group labels on people rather than see them as individuals. Religion fuels both. All violent enmities in the world today fuel their tanks at this holy gas-station. Those of us who have for years politely concealed our contempt for the dangerous collective delusion of religion need to stand up and speak out. Things are different after September 11th. Let's stop being so damned respectful!

A revised version of a paper written for the Freedom From Religion Foundation, Madison, Wisconsin, reproduced by kind permission of Richard Dawkins.

The "Alabama Insert": A Study in Ignorance and Dishonesty

The "Alabama Insert": A Study in Ignorance and Dishonesty, *Journal of the Alabama Academy of Science* (Jan 97) - transcript of a lecture by **Richard Dawkins** from the Franklin Lectures in Science & Humanities, Auburn University April 1, 1996.

Text of the amendment to the Alabama Course of Study - Science, adopted by the Alabama State Board of Education in 1995, and to be included in all state-approved biology textbooks beginning fall, 1996:

A MESSAGE FROM THE ALABAMA STATE BOARD OF EDUCATION
[to be pasted in all biology textbooks]

This textbook discusses evolution, a controversial theory some scientists present as a scientific explanation for the origin of living things, such as plants, animals and humans.

No one was present when life first appeared an earth. Therefore, any statement about life's origins should be considered as theory, not fact.

The word "evolution" may refer to many types of change. Evolution describes changes that occur within a species. (White moths, for example, may "evolve" into gray moths.) This process is microevolution, which can be observed and described as fact. Evolution may also refer to the change of one living thing to another, such as reptiles into birds. This process, called macroevolution, has never been observed and should be considered a theory. Evolution also refers to the unproven belief that random, undirected forces produced a world of living things.

There are many unanswered questions about the origin of life which are not mentioned in your textbooks, including:

Why did the major groups of animals suddenly appear in the fossil record (known as the Cambrian Explosion)?

Why have no new major groups of living things appeared in the fossil record in a long time?

Why do major groups of plants and animals have no transitional forms in the fossil record?

How did you and all living things come to possess such a complete and complex set of "instructions" for building a living body?

Study hard and keep an open mind. Someday you may contribute to the theories of how living things appeared on earth.

Journal of the Alabama Academy of Science, Vol. 68, No.l, January, 1997.

Franklin Lectures in Science & Humanities Auburn University April 1, 1996

THE "ALABAMA INSERT": A STUDY IN IGNORANCE AND DISHONESTY

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As a former prime minister of my country, Neville Chamberlain once said: "I have here a piece of paper." It says "A message from the Alabama Stare Board of Education." This is a flier that is designed to be - *ordered* to be - stuck into the front of every textbook of Biology used in the public schools. What I thought I would do, with your permission, is to depart from the prepared text I brought with me. Instead I should like to go through every sentence of this document, one by one.

> "THIS TEXTBOOK DISCUSSES EVOLUTION, A CONTROVERSIAL THEORY THAT SOME SCIENTISTS PRESENT AS A SCIENTIFIC EXPLANATION FOR THE ORIGIN OF LIVING THINGS SUCH AS PLANTS, ANIMALS, AND HUMANS."

This is dishonest. The use of "*some* scientists" suggests the existence of a substantial number of respectable scientists who do not accept evolution. In fact, the proportion of qualified scientists who do not accept evolution is tiny. A few so called "creation scientists" are much touted as possessing PhDs, but it does not do to look too carefully where they got their PhDs from nor the subjects they got them in. They are, I think, never in relevant subjects. They are in subjects perfectly respectable in themselves, like marine engineering or chemical engineering, which have nothing to do with the matter at hand.

> "NO ONE WAS PRESENT WHEN LIFE FIRST APPEARED ON EARTH"

Well, that is true.

> "THEREFORE, ANY STATEMENT ABOUT LIFE'S ORIGINS SHOULD BE CONSIDERED AS THEORY, NOT FACT."

That's also true but the word theory is being used in a misleading way. Philosophers of science use the word theory for pieces of knowledge that anybody else would call fact, as well as for ideas that are little more than a hunch. It is strictly only a theory that the earth goes around the sun. It is a theory but it's a theory supported by all the evidence. A fact is a theory that is supported by all the evidence. What this is playing upon is the ordinary language meaning of theory which implies something really pretty dubious or which at least will need a lot more evidence one way or another.

For example, nobody knows why the dinosaurs went extinct and there are various theories of it which are interesting and for which we hope to get evidence in the future. There's a theory that a meteorite or comet hit the earth and indirectly caused the death of the dinosaurs. There's a theory that the dinosaurs were killed by competition from mammals. There's a theory that they were killed by viruses. There are various other theories and it is a genuinely open question which (at the time of speaking) we need more evidence to decide. That is also true of the origin of life, but it is not the case with the theory of evolution itself. Evolution is as true as the theory that the world goes around the sun.

While talking about the theories of the dinosaurs I want to make a little aside. You will sometimes see maps of the world in which the places where people speak different languages are shaded. So, you'll say, "English is spoken here," "Russian is spoken there," "French is spoken here, etc. " And that's fine; that's exactly what you would expect because people speak the language of their parents.

But imagine how ridiculous it would be if you could construct a similar map for theories of, say, how the dinosaurs went extinct. Over here they all believe in the meteorite theory. Over on that continent they all believe the virus theory, down here they all believe the dinosaurs were driven extinct by the mammals. But if you think about it that's more or less exactly the situation with the world's religions.

We are all brought up with the religion of our parents, grandparents and great-grandparents and by golly that just happens to be the one true religion. Isn't that remarkable! Creation myths themselves are numerous and varied. The creation myth that happens to be being taught to the children of Alabama is the Jewish creation myth which in turn was taken over from Babylonian creation myths and was first written down not very long ago when the Jews were in captivity. There's a tribe in West Africa that believes that the world was created from the excrement of ants. The Hindus, I am told, believe that the world was created in a cosmic butter churn. No doubt every tribe and every valley of New Guinea has its own origin myth. There is absolutely nothing special about the Jewish origin myth, which is the one we happen to have in the Christian world.

Moving on in the "Alabama Insert" as I shall call it.

> "THE WORD 'EVOLUTION' MAY REFER TO MANY TYPES OF CHANGES. EVOLUTION DESCRIBES CHANGES THAT OCCUR WITHIN A SPECIES (WHITE MOTHS, FOR EXAMPLE, MAY "EVOLVE" INTO GRAY MOTHS). THIS PROCESS IS CALLED MICROEVOLUTION WHICH CAN BE OBSERVED AND DESCRIBED AS FACT. EVOLUTION MAY ALSO REFER TO

> CHANGES OF ONE LIVING THING INTO ANOTHER SUCH AS REPTILES CHANGING INTO BIRDS. THIS PROCESS CALLED MACROEVOLUTION HAS NEVER BEEN OBSERVED AND SHOULD BE CONSIDERED A THEORY."

The distinction between microevolution and macroevolution is becoming a favorite one for creationists. Actually, it's no big deal. Macroevolution is nothing more than microevolution stretched out over a much greater time span.

The moth being referred to, I presume, is the famous peppered moth, *Biston betularia*, studied in England by my late colleague Bernard Kettlewell. It is a famous story about how, in the Industrial Revolution when the trees went black from pollution, the peppered pale colored version of this moth was eaten by birds because it was conspicuous against the black tree trunks. After the Industrial Revolution years, the black moths became by far the majority in industrial areas of England. But if you go into country areas where there is no pollution, the original peppered variety is still in a majority. I presume that's what the document is referring to.

The point about that story is that it's one of the few examples we know of genuine natural selection in action. We are not normally privileged to see natural selection in action because we don't live long enough. The Industrial Revolution, however unfortunate it may have been in other respects, did have the fortunate by-product of changing the environment in such a way that you could study natural selection.

To study other examples of natural selection I recommend the book *The Beak of the Finch* by J. Weiner. He is describing the work of Peter and Rosemary Grant on the Galapagos finches. Those finches, perhaps more than any other animal, inspired Charles Darwin himself. What the Grants have done studying Galapagos Island finches is actually to sample populations from year to year and show that climatic changes have immediate and dramatic effects on the population ratios of various physical structures such as beak sizes.

Darwin was inspired by the example of the Galapagos finches; he was also inspired by the examples of domestication.

These are all domestic dogs (**Slide 1**) except the top one which is a wolf. The point of it is, as observed by Darwin, how remarkable that we could go by human artificial selection from a wolf ancestor to all these breeds - a Great Dane, a Bulldog, a Whippet, etc. They were all produced by a process analogous to natural selection - artificial selection. Humans did the choosing whereas in natural selection, as you know, it is nature that does the choosing. Nature selects the ones that survive and are good at reproducing, to leave their genes behind. With artificial selection, humans do the choosing of which dogs should breed and with whom they should mate.

These plants (**Slide 2**) are all members of the same species. They are all descended quite recently from the wild cabbage *Brassica olearacea* and they are very different cauliflower, brussels sprouts, kale, broccoli, etc. This great variety of vegetables, which look completely different, has been shaped - they have been sculpted - by the process of artificial selection from the same common ancestor.

That's an example of what can be achieved in a few centuries when the selection is powerful enough. When the selection goes on for thousands of centuries the change is going to be correspondingly greater - that's macroevolution. It's just microevolution going on for a long time.

It's difficult for the human mind to grasp how much time geology allows us, so various picturesque metaphors have been developed. The one I like is as follows: I stand with my arm outstretched and the distance from the center of my tie to my fingers represents the total time available since life began. That's about four thousand million years. Out to about my shoulder we still get nothing but bacteria. At my elbow you might be starting to get slightly more complicated cells - eukaryotic cells - but still single cells. About mid-forearm you start getting multicellular organisms, animals you can see without a microscope. At my palm you would get the dinosaurs. Somewhere toward the end of my finger you would get the mammals. At the beginning of my nail you would get early humans. And the whole of history - all of documented written human history, all the Babylonians, Biblical history, Egyptians, the Chinese, the whole of recorded history would fall as the dust from a nail file across the tip of my furthest finger.

This is hard for the human brain to grasp, time spans of that order. Remember that the time represented by the dust from the nail includes the time it took these cabbage varieties to evolve by artificial selection (human selection) and dogs to evolve from wolves. Just think how much change could be achieved by natural selection during the thousands of millions of years before recorded history.

To reinforce that point there was a theoretical calculation made by the great American botanical evolutionist, Ledyard Stebbins. He wanted to calculate theoretically how long it would take to evolve from a tiny mouse sized animal (ancestor) to a descendant animal the size of an elephant. So what we are talking about is a selection pressure for increased size. Selection pressure means that in any generation slightly larger than average individuals have a slight advantage. They are slightly more likely to survive for whatever reason, slightly more likely to reproduce. Stebbins needed a number to represent that selection pressure, a way to show how strong to assume it to be. He decided to assume it (the pressure) to be so weak that you couldn't actually detect it if you were doing a field study out there trapping mice.

So Stebbins assumed his theoretical selection pressure to be so weak that it is undetectable, it vanishes in the sampling error of an ordinary research study. Nevertheless it's there. How long would it take under this small but relentless pressure for these mouse-like animals to grow and grow over the generations until they became the size of an elephant? He concluded that it would take about 20,000 generations. Well, mouse generations would be several in a year, elephant generations would take several years. Let's compromise and assume one year per generation. Even at 5 years per generation, that's not many years, say 100,000 years at the most. Well, 100,000 years is too short to be detected on the geological time scale for most of geologic history.

For most characteristics a selection pressure as weak as that, so weak that you couldn't even measure it, is sufficiently strong as to propel evolution so fast that it appears to be instantaneous on the geological time scale. In practice it probably isn't even as fast as that, but geological time is so vast that there is plenty of time for the evolution of all of life to have happened.

Another theoretical calculation was made by the Swedish biologist, Dan Nilsson. He took up the question which Darwin himself was interested in - the eye, the famous eye, the darling of creationist literature. Darwin himself recognized the eye as a difficult case because it is very complicated. Many people have thought, wrongly, that the eye is a difficult problem for evolutionists because - "Doesn't it have to be all there with all the bits working for the thing to work?"

No. Of course they don't all have to be there. An animal that has half an eye can see half as well as an animal with a whole eye. An animal with a quarter eye has a quarter vision. An animal with 1/100 eye has 1/100 quality vision. It's not quite as simple as that. The point 1 am making is that you can be aided in your survival by every little tiny increment in quality of eyesight. If you have 1/100 quality eyesight, you can't see an image but you can see light and that might be useful. The animal might be able to tell which direction the light is coming from or which direction a shadow is coming from which could portend a predator. There are all sorts of things you could do that help you to survive if you have a small fraction of an eye, to survive better than an animal which has no eye at all. With 1/100 of an eye you can just about survive. With 2/100 of an eye you can survive a little better. There is a slow, gradual ramp of increasing probability of surviving as the eye gradually gets better.

Going back to the question of the rate at which all this happens, Nilsson did a computer modeling exercise of the evolution of the eye (**Slide 3**). He starts from a computer model which is not really eye shaped at all but is just a flat sheet of light sensitive cells. You've got to start somewhere. You could start before that if you wanted to, but that's where he started. He made the computer gradually change the shapes of this model eye. The only rule was that the changes had to be small and each change had to result in an improvement in vision. The beautiful thing about the eye is that by using the actual rules of physics, the ordinary rules of optics, you can calculate how good each of the hypothetical intermediates would be at forming an image.

These intermediates all formed spontaneously in the computer as a result of gradual improvement in what the computer could measure as the optical quality of the model eye, and it goes all the way from a flat sheet of cells to a proper camera eye with a lens such as you might see in a fish. It is even better than that. The exact focusing of the lens is precisely as it should be. The details of this are written down in Nilsson's paper. By feeding in assumptions which are based upon field work in population genetics he was able to make calculations as to how long it would plausibly take under realistic conditions of natural selection. This is similar to the Stebbins calculation of how long it would take to go from the start of the series to the end. Once again it was startlingly fast. Nilsson calculated that it would take fewer than half a million generations. The sort of small animals we are talking about, in which the eye originally evolved, would probably have had about 1 generation/year. Half a million years is a very short time on the geologic time scale.

Therefore, it's not surprising that when you look around the animal kingdom you find all the intermediates you could wish for in the evolution of the eye, in various groups of worms, etc. The eye has evolved no less than 40 times independently around the animal kingdom, and possibly as many as 60 times. So, "the" eye is really some 40-60 different eyes and it evolves very rapidly and exceedingly easily. There are 9 different optical principles that have been used in the design of eyes and all 9 are represented more than once in the animal kingdom.

> "EVOLUTION ALSO REFERS TO THE UNPROVEN BELIEF THAT RANDOM, UNDIRECTED FORCES PRODUCED A WORLD OF LIVING THINGS. "

Where *did* this ridiculous idea come from that evolution has something to do with randomness? The theory of evolution by natural selection has a random element -- mutation - but by far the most important part of the theory of evolution is non-random: natural selection. Mutation is random. Mutation is the process whereby parent genes are changed, at random. Random in the sense of not directed toward improvement. Improvement comes about through natural selection, through the survival of that minority of genes which are good at helping bodies survive and reproduce. It is the non-random natural selection we are talking about when we talk about the directing force which propels evolution in the direction of increasing complexity, increasing elegance and increasing apparent design.

The statement that "evolution refers to the unproven belief that random undirected forces. . ." is not only unproven itself, it is stupid. No rational person could believe that random forces could produce a world of living things.

Fred Hoyle, the eminent British astronomer who is less eminent in the field of biology, has likened the theory of evolution to the following metaphor: "it's like a tornado blowing through junk yard and having the luck to assemble a Boeing 747. " His statement is a classic example of the erroneous belief that natural selection is nothing but a theory of chance. A 'Boeing 747' is the end product that any theory of life must explain. The riddle for any theory to answer is, "how do you get complicated, statistically improbable apparent design? " Darwin's theory of evolution by natural selection is the only known theory that can answer this riddle. It is also supported by a great deal of evidence. With his explanation Darwin, in effect, smears out the chance or "luck" factor. There is luck in the theory, but the luck is found in small steps. Each generational step in the evolutionary process is only a little bit different from the step before. These little bits of difference are not too great to come about by chance, by mutation. However if, after the accumulation of a sufficient number of these small steps (perhaps 100), one after the other, you've got something like an eye at the end of this process, it could not have come all of a sudden by chance. Each individual step could occur by chance, but all 100 steps together could not. All 100 steps are pieced together cumulatively by natural selection.

Another metaphor along these lines is of a bank robber who went into a bank and started fiddling with the combination lock on the safe. Theoretically the thief could fiddle with the lock and have the luck to open the safe. Of course you know in practice he couldn't do that. That's why your money is safe in the bank. But just suppose that every time you twiddled that knob and got a little bit closer to the correct number, a one dollar bill fell out of the safe. Then when you twiddled it another way and got a little closer still, another dollar fell out. You would very rapidly open the safe. It's like that with natural selection. Each step has a little bit of luck but when the steps are put together you end up with something that looks like a 'Boeing 747'.

> "THERE ARE MANY UNANSWERED QUESTIONS ABOUT THE ORIGIN OF LIFE WHICH ARE NOT MENTIONED IN YOUR TEXTBOOK INCLUDING: WHY DID THE MAJOR GROUPS OF ANIMALS SUDDENLY APPEAR IN THE FOSSIL RECORD KNOWN AS THE "CAMBRIAN EXPLOSION."

We are very lucky to have fossils at all. After an animal dies many conditions have to be met if it is to become a fossil, and one or other of those conditions usually is not met. Personally, I would consider it an honor to be fossilized but I don't have much hope of it. If all the creatures which had ever lived had in fact been fossilized we would be wading knee deep in fossils. The world would be filled with fossils. Perhaps it is just as well that it hasn't happened that way.

Because it is particularly difficult for an animal without a hard skeleton to be fossilized, most of the fossils we find are of animals with hard skeletons - vertebrates with bones, mollusks with their shells, arthropods with their external skeleton. If the ancestors of these were all soft and then same offspring evolved a hard skeleton, the only fossilized animals would be those more recent varieties. Therefore, we expect fossils to appear suddenly in the geologic record and that's one reason groups of animals suddenly appear in the Cambrian Explosion.

There are rare instances in which the soft parts of animals are preserved as fossils. One case is the famous Burgess Shale which is one of the best beds from the Cambrian Era (between 500 million and 600 million years ago) mentioned in this quotation. What must have happened is that the ancestors of these creatures were evolving by the ordinary slow processes of evolution, but they were evolving before the Cambrian when fossilizing conditions were not very good and many of them did not have skeletons anyway. It is probably genuinely true that in the Cambrian there was a very rapid flowering of multicellular life and this may have been when a large number of the great animal phyla did evolve. If they did, their essential divergence during a period of about 10 million years is very fast. However, bearing in mind the Stebbins calculation and the Nilsson calculation, it is actually not all that fast. There is some recent evidence from molecular comparisons among modern animals which suggests that there may not have been a Cambrian explosion at all, anyway. Modern phyla may well have their most recent common ancestors way back in the Precambrian.

As I said, we're actually lucky to have fossils at all. In any case, it is misleading to think that fossils are the most important evidence for evolution. Even if there were not a single fossil anywhere in the earth, the evidence for evolution would still be utterly overwhelming. We would be in the position of a detective who comes upon a crime after the fact. You can't see the crime being committed because it has already happened. But there is evidence lying all around. To pursue any case, most detectives and most courts of law are happy with 2-3 clues that point in the right direction.

Even discounting fossils, the clues that are left for us to see that prove the truth of evolution are numbered in the tens of millions. The number of clues, the sheer weight of evidence, totally and utterly, sledgehammeringly, overwhelmingly strongly supports the conclusion that evolution is true - unless you are prepared to believe the Almighty deliberately faked the evidence in order to make it look as though evolution is true. (And there are people who believe that.)

The evidence comes from comparative studies of modern animals. If you look at the millions of modern species and compare them with each other - looking at the comparative evidence of biochemistry, especially molecular evidence - you get a pattern, an exceedingly significant pattern, whereby some pairs of animals like rats and mice are very similar to each other. Other pairs of animals like rats and squirrels are a bit more different. Pairs like rats and porcupines are a bit more different still in all their characteristics. Others like rats and humans are a bit more different still, and so forth. The pattern that you see is a pattern of cousinship; that is the only way to interpret it. Some are close cousins like rats and mice; others are slightly more distant cousins (rats and porcupines) which means they have a common ancestor that lived a bit longer ago. More distinctly different cousins like rats and humans had a common ancestor who lived a bit longer ago still. Every single fact that you can find about animals is compatible with that pattern.

Similarly you can look at the geographical distribution of an animal species. Why do animals in the Galapagos Islands more closely resemble animals on neighboring islands and resemble less the animals on the mainland? It's all exactly what you would expect if evolution goes on in isolation on islands with occasional island hopping. New foci for evolution start with migration from mainland to island and then progress from there to other islands.

If you look at the imperfections of nature you see evidence for evolution. **Slide 4** shows animals that don't necessarily fly but are at plausible intermediate stages on the way to flight. These stages are relevant to the discussion of what's the use of half an eye or what's the use of half a wing. These animals all glide and by gliding save themselves from falling out of trees.

There are two different ways of being a flat fish. The top fish in **Slide 5** is a skate; the bottom one is a flounder. The skate is flat the way a designer might have designed: flattened out on its belly as symmetrically as it can be. The flounder is not symmetrical because when its ancestors went flat they lay on their side, their right side. That meant that the right eye was looking down into the bottom of the sea (not good). Over many generations, natural selection favored the migration of the right eye from the underside to the top. The whole skull became distorted in an interesting way - no designer would ever have built a fish like that. The flounder has its history written all over it. Its ancestors were once free swimming in the normal way, like a trout or a salmon, and then over many generations changed into a flat fish.

> "WHY HAVE NO NEW MAJOR GROUPS OF LIVING THINGS APPEARED IN THE FOSSIL RECORD FOR A LONG TIME?"

We are moving well down the list of the Alabama State Board of Education. In zoology, "major groups" would be called phyla - a phylum being a category such as mollusks, which includes snails and shellfish; echinoderms, which are starfish, sea urchins and so on; chordates, which are animals with spinal cords, including ourselves; arthropods which include insects and crustaceans. The question is, "Why have no major ones appeared in a long time?"

Well, major groups don't and shouldn't, according to the Darwinian Theory, just appear. They evolve gradually. Major phyla are different from each other, though ancestrally they were like brothers. They diverged and became separate species, then separate families, then separate orders. It takes time to do that.

Think of this analogy. Suppose you have a great oak tree with huge limbs at the base and smaller and smaller branches toward the outer layers where finally there are just lots and lots of little twigs. Obviously the little tiny twigs appeared most recently. The larger boughs appeared a long time ago and when they did appear, they were little twigs. What would you think if a gardener said, "Isn't it funny that no major boughs have appeared on this tree in recent years, only small twigs?" You'd say he is stupid.

"WHY DO MAJOR NEW GROUPS OF PLANTS AND ANIMALS HAVE NO TRANSITIONAL FORMS IN THE FOSSIL RECORD."

It's amazing how often this is stated in the creationist literature. It's amazing because it simply isn't true. There are plenty of transitional forms. There are gaps, of course, for reasons I have stated - not all animals fossilize. But what is significant is that not a single fossil has turned up in the wrong place. Fossils are all in the right order. Creationists know that fossils all appear in the right order and it is quite an embarrassment for them. The best explanation they have come up with so far is based on Noah's flood. They say that when the great flood came the animals all rushed for the hills. The clever ones all got to the top of the hill while the stupid ones were stuck at the bottom and that's why the fossils are all neatly laid out in just the right order!

Part of the error about transitional forms may come from a misreading of a theory by my colleagues Niles Eldredge and Stephen J. Gould. Their theory is called 'punctuated equilibrium'. It is really about rapid gradualism or, to say it another way, gradual change that occurs rapidly separated by periods of stasis when nothing changes at all. Eldredge and Gould are rightly annoyed about the misuse of their idea by creationists, who in my terminology, think punctuated equilibrium is about huge Boeing 747 type mutations. I quote Stephen Gould, "We proposed punctuated equilibrium to explain trends; it is infuriating to be quoted again and again, whether through design or stupidity I do not know, as admitting 'the fossil record includes no transition forms'. Transitional forms are generally lacking at the species level but they are abundant between larger group forms." Dr. Gould goes on, "I am both angry at and amused by the creationists and mostly I am deeply sad."

Finally, there is a semantic point about transitional forms. Zoologists, when they classify, are forced by the rules of the game to put each specimen in one species or another. In the classification business we are not allowed to say, "Well this is half-way between *Homo sapiens* and *Homo erectus*". People who dig up human fossils will always be forced to choose between one or the other. Is it *Homo erectus* or archaic *Homo sapiens*? It is forced to be one or the other. Given this definition, it is almost a legalistic point that fossils have got to be classified as one or the other. The analogy I'd offer is this. When you reach the age of majority - legal age - of 18 in Alabama you can vote. So, at the stroke of midnight on your eighteenth birthday you become an adult. Suppose somebody were to say, "Isn't it remarkable, there are no intermediates between children and adults?" That would be ridiculous.

> "HOW DID YOU AND ALL LIVING THINGS COME TO POSSESS SUCH A COMPLETE AND COMPLEX SET OF INSTRUCTIONS FOR BUILDING A LIVING BODY."

The set of instructions is our DNA. We got it from our parents and they got it from their parents. We can all look back through the generations, through 4000 million years to a tiny bacterium who lived in the sea and was the ancestor of us all. We are all cousins.

We can all look back at our ancestors and claim (it's a proud claim) we are all descended from the elite. Not a single one of my ancestors died in infancy; they all reached adulthood. Not one of my ancestors failed to achieve at least one heterosexual copulation. All our ancestors were good at surviving and reproducing. We are descended from an elite.

Thousands of our ancestors' contemporaries failed. None of our ancestors did. Our DNA is DNA that has come down through thousands of millions of successful ancestors. We have inherited DNA that is pretty good at the job of surviving and, when DNA survives, it programs bodies to be good at surviving and reproducing. The world is bound to become filled with DNA that is good at surviving and reproducing. The DNA that is alive today has survived thousands of filters. Millions of generations of ancestors that survived as a consequence of the efficient programming of their DNA, have produced an unbroken lineage. There is more to it than that. Evolution is progressive - not all the time, not uniformly - but generally it is progressive. Lineages become progressively better at what they do. Predators get better at catching prey. They have to because prey become better at getting away from predators. Just as in the human arms race there must be advances on one side to counterbalance advances on the other side.

Just a few examples of animals I would consider to be at the end of an arms race are: butterflies and leaf-insects (related to stick insects) that look exactly like leaves; and bugs that look like rose thorns and sit on rose stems. All of these are the result of generations of natural selection in which predators have been put off eating the ancestors of these insects. The ancestors that look most like leaves or rose thorns were the least likely to end up in predators' bellies.

The leafy sea dragon is a fish, related to sea horses. It has 'fronds' that look exactly like seaweed for camouflage. This constitutes the end of an arms race in which fish that did not look like seaweed were eaten, whereas fish that did look like seaweed swam on to reproduce another day.

It's not all just survival, it's also winning mates. Birds of paradise are brightly colored because that's what females like. Genes that make pretty males are more likely to get mates and have children. This is an arms race between the salesmanship of males and the sales resistance of females.

Finally, one of the most rapid and dramatic stories of evolution -- the evolution of the human brain from the brain of ape-like ancestors. The human brain constitutes the major difference between us and our close cousins, the great apes. Fossil evidence shows that our brain has blown up like a balloon during the last 2 or 3 million years as our evolution passed through the ancestral stage *Australopithecus*, *Homo erectus* and finally *Homo sapiens*. No one knows why the human brain blew up in this way. I suspect again it was like some kind of arms race - some kind of positive feedback.

> "STUDY HARD AND KEEP AN OPEN MIND. SOMEDAY YOU MAY CONTRIBUTE TO THE THEORIES OF HOW LIVING THINGS APPEARED ON EARTH."

Well, at last we have found something we can agree with. This seems to me to be an admirable sentiment. I really have less trouble than some of my colleagues with so-called creation science being taught in the public schools as long as evolution is taught as well. By all means let creation science be taught in the schools. It should take all of about 10 minutes to teach it and then children can be allowed to make up their own minds in the face of evidence. For children who study hard and keep an open mind, it seems to me utterly inconceivable that they could conclude anything other than that evolution is true.

Posted by John Catalano

Robert Todd Carroll

SkepDic.com

The Skeptic's Refuge

Internet Bunk features WWW sites that provide false, misleading or deceptive information regarding scientific matters or alleged paranormal or supernatural events. Because there are millions of such sites, we try to present only the most egregious and offensive.

The Alternative Science Pages of Richard Milton

Richard Milton's defense of "alternative" science is a textbook case of **Why Intelligent People Believe Dumb Things**. Nearly every logical fallacy and psychological foible that hinders us from being fair and accurate in our assessment of claims and arguments regarding science and the paranormal is exemplified by Milton.

selective thinking

Let's begin with his version of the "they laughed at Galileo, so I must be right" fallacy, a *non sequitur* variation of selective thinking.

In his book *Alternative Science,* and on his website under what he calls **Skeptics who declared discoveries and inventions impossible,** Milton lists a number of inventors and scientists who struggled to get their ideas accepted. Many were ridiculed along the way. But, like many others who commit this fallacy, Milton omits some important, relevant data. He does not mention that there are also a great number of inventors, scientists and thinkers who were laughed at and whose ideas have never been accepted. Many people accused of being crackpots turned out to be crackpots. Some did not. Thus, being ridiculed and rejected for one's ideas is not a sign that one is correct. It is not a sign of anything important about the idea which is being rejected. Thus, finding large numbers of skeptics who reject ideas as being "crackpot ideas" does not strengthen the likelihood of those ideas being correct. The number of skeptics who reject an idea is *completely irrelevant* to the truth of the idea. Ideas such as alien abduction, homeopathy, psychokinesis, orgone energy, ESP, free energy, spontaneous human combustion, and the rejection of evolution--all favored by Milton--are not supported in the least by the fact that these ideas are trashed by thousands of skeptics.

anomalies and coincidences

Like many believers in the paranormal, Milton is quite impressed with the statistical data of people defending claims that they have scientific evidence for such things as telepathy or psychokinesis.

> **significance to anomalies and coincidences.** ---John Allen Paulos

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He cites Dean Radin who defends the ganzfeld experiments and The Princeton Engineering Anomalies Research. In both cases, impressive statistics are used to support the belief in paranormal phenomena. It does not seem to occur to Milton that there might be alternative explanations for the statistics. Nor does it seem to occur to him that the defenders of these claims have not done a very good job of providing compelling evidence of anything significant. Milton seems to think that the parapsychologists are rejected because they pose some sort of threat to mainstream science. There is no threat. If a reasonable explanation of paranormal phenomena is ever made and compelling evidence is produced to support belief in ESP, etc., mainstream scientists will jump on the bandwagon as they have in the past (see below, the examples of continental drift and pre-Clovis Americans).

ad hominen

Another common fallacy committed by Milton is to attack the motives of those who criticize and reject "crackpot ideas." Milton claims

> **Some areas of scientific research are so sensitive and so jealously guarded by conventional science that anyone who dares to dabble in them -- or even to debate them in public -- is likely to bring down condemnation from the scientific establishment on their head, and risk being derided, ridiculed or even called insane.***

These allegations may be true, but they are also irrelevant to whether the "sensitive" ideas are true or not. The charges are not true in at least two areas where Milton claims it is forbidden to do research: cold fusion and Darwinism. Research continues at several labs into cold fusion, although it is apparently the case that the Department of Energy considers cold fusion to be forbidden territory. [Note: In March 2004, the Department of Energy said it would review over 15 years of cold fusion research (what it calls "low-energy nuclear reactions." The report came out Dec. 1, 2004. The bottom line? "While significant progress has been made in the sophistication of calorimeters since the review of this subject in 1989, the conclusions reached by the reviewers today are similar to those found in the 1989 review.")] Darwinism (natural selection), on the other hand, has been attacked from within the ranks of scientists almost from its inception. Even Darwin didn't think natural selection could completely explain evolution (See *The Descent of Man, and Selection in Relation to Sex*). Like many critics of evolution, Milton does not understand Darwinism. But that is another fallacy.

the straw man

Milton's attack on Darwinism is an attack on a position quite distinct from the theory of natural selection. Milton attacks an idea few, if any, hold today. He attacks an ideology he characterizes as a godless philosophy of materialism, embracing the meaningless of life in a dog-eat-dog world of brute aggression. Darwinism implies nothing about the existence of God or a spiritual realm. It implies nothing about a Creator who does or does not meddle in evolution. It implies nothing about the kind of social world we have or should have. An evolutionary biologist is certainly free to believe that God designed evolution.

more selective thinking

Milton ignores the fact that science has nothing to gain by believing what is false. Unlike Milton, who sees scientific beliefs as essentially ideological, scientists as a group have nothing at stake should the facts of nature turn out to be otherwise than currently believed. Of course, individual scientists from time to time get stuck in ideological and idiosyncratic corners, but science as a whole is an enterprise that is self-correcting. He attacks scientists for not accepting the criticisms of thinkers and writers who criticize Darwinism. But he does not see that these ideas are rejected either because their authors are barking up the wrong tree (attacking straw men) or they have not made their case convincingly. Milton should review the Alfred Wegner case for an example of how science really works, because it is quite different from his notion of conspirators guarding the gates of error and rejecting such things as homeopathy or iridology "because they threaten to violate the accepted canons of scientific rationalism."* Milton seems to have little appreciation for the fact that it is easy to find confirmation for just about any hypothesis and that one must constantly be on guard against confirmation bias, self-deception, wishful thinking, and other psychological hindrances that can lead to pathological science. Examples abound in his pages, but one of the weakest arguments he has is given in favor of a Russian astrophysicist, Mark Zilberman, who has found a correlation between the 11-year cycle of solar activity and winners of the lottery in Russia and France. Milton seems to think this is an amazing feat and indicative of ESP "modulated by external geophysical factors." He can't understand why scientists are not beating a path to Zilberman's door.

Alfred Wegener and continental drift

In *The Origin of Continents and Oceans* Wegener proposed the theory of continental drift against the prevailing theory that the earth was formed by cooling from a molten state and contractions. "Wegner's mode of reasoning lent itself to criticisms and counter-arguments. Wegener made assertions that could be checked and refuted as further evidence came in. He left room for his speculations to be superseded" (Radner & Radner, 92). Wegener did not have disciples, but sympathizers who "acted like scientists." Yet, Wegner's idea that continents move was rejected by most scientists when it was first proposed.

Stephen Jay Gould notes that when the only American paleontologist defending the new theory spoke at Antioch college (where Gould was an undergraduate at the time), most of the audience dismissed the speaker's views as "just this side of sane" (Gould, 1979, 160). A few years later, all the early critics of the new theory would accept it as true. Why? Was it simply a matter of Wegener and a few others jumping the gun by accepting a new theory before the evidence was sufficient to warrant assent? Were the latecomers 'good' scientists, waiting for more facts to confirm the theory? Gould's view is that dogmatic adherence to the view that the ocean floor is solid and unchanging was the main stumbling block to acceptance of the new theory. Most scientists rejected continental drift because it did not fit with their preconceived ideas about the nature of the earth's crust. They assumed that if continents did drift they would leave gaping holes in the earth. Since there were no gaping holes in the earth, it seemed unreasonable to believe that continents move. The theory of continental drift, says Gould, "was dismissed because no one had devised a physical mechanism that would permit continents to plow through an apparently solid oceanic floor." Yet, "during the period of nearly universal rejection, direct evidence for continental drift--that is, the data gathered from rocks exposed on our continents--was every bit as good as it is today." Continental drift was considered *theoretically* impossible by some, even if it were *physically* possible for continents to move. The new theory could not be made to fit the theoretical model of the earth then universally accepted.

The theory of plate tectonics was then proposed--the idea that the continents ride on plates which are bounded by areas where new crust is being created from within the planet and old crust is falling into trenches. This provided *a mechanism which explains how continents drift.* Continental drift, according to Gould, came to be accepted not because more facts had been piled up, but because it was a necessary consequence of the new theory of plate tectonics. More facts were piled up, though--facts for the new theory of plate tectonics, of which the theory of continental drift is an essential element. Today, it is taken as a fact that continents move. Yet, the exact mechanism by which plates move is still incompletely understood. This area of science will no doubt generate much debate and theorizing, testing of hypotheses, rejection and/or refinement of ideas.

The continental drift episode is a good example of how science works. To someone who does not understand the nature of science, the early rejection of the idea of continental drift might appear to show how dogmatic scientists are about their pet theories. If scientists had not been so devoted to their belief that the earth's crust is solid and immovable, they would have seen that continents can move. That is true. However, the fact that Wegener's theory turned out to be correct does not mean that he and his few early followers were more reasonable than the rest of the scientific community. After all, *Wegener did not know about plate tectonics and he did not provide an acceptable explanation as to how continents might move.* Wegener argued that gravity alone could move the continents. Gould notes: "Physicists responded with derision and showed mathematically that gravitational forces are far too weak to power such monumental peregrination." Alexis du Toit, a defender of Wegener's theory, argued for radioactive melting of the ocean floor at continental borders as the mechanism by which continents might move. "This ad hoc hypothesis added no increment of plausibility to Wegener's speculation," according to Gould (1979, 163).

It is true that the idea that the earth's crust is solid and immovable has been proved wrong, but Wegener didn't prove that. What his theory could explain (about rocks and fossils, etc.) other theories could explain equally well. However, in the end, the idea of continental drift prevails. It prevails because the dogmatism of science--the tendency to interpret facts in light of theories--is not absolute but relative. Gould notes with obvious admiration that a distinguished stratigraphy professor at Columbia University (where Gould did graduate work), who had initially ridiculed the theory of drifting continents, "spent his last years joyously redoing his life's work" (Gould, 1979, 160). It is hard to imagine a comparable scene involving any of the scientists admired by Milton.

ad hoc hypotheses

One characteristic of Milton's "alternative" sciences that distinguishes them from real science is their reliance on ad hoc hypotheses to explain the mysterious mechanisms behind homeopathy, psychokinesis, ESP, perpetual motion machines, spontaneous human combustion, etc. How *homeopathy* is explained will serve to demonstrate this point.

Homeopathy is a system of medical treatment based on the use of minute quantities of remedies that in massive doses produce effects similar to those of the disease being treated. Advocates of homeopathy think that concoctions with as little as one molecule per million can stimulate the "body's healing mechanism." They even believe that the potency of a remedy increases as the drug becomes more and more dilute. Some drugs are diluted so many times that they don't contain any molecules of the substance that was initially diluted, yet homeopaths claim that these are their most potent medications! Critics maintain that such minute doses are unlikely to have any significant effect on the body. The critics base their belief on what they know about the body and how it works. Homeopaths base their belief on anecdotes and the metaphysical notion that like heals like. They have resorted to various ad hoc hypotheses to explain how a negligible or non-existent amount of a substance could have any effect on the body. They have appealed to various healing "energies" of "vital forces" bringing this, that, or the other into "harmony." The explanation that seems to have the most favor among "alternative" scientists is, however, the theory of water memory, the notion that "that during serial dilution the complex interactions between the solvent (water) molecules are permanently altered to retain a "memory" of the original solute material."*

Not only is there no evidence that such memory occurs, there is no explanation as to *how* such an event could occur. Current chemical knowledge cannot explain how water could "remember" a molecule that is no longer present. Thus, the expected and reasonable response of the scientific community when presented with homeopathic studies that support the notion that a homeopathic potion is effective is to assume that something else besides efficacy of the potion explains the results. Usually, that something else is the placebo effect, bias in experimental design, methodological or calculative errors, or even fraud. Until homeopaths can provide a reasonable explanation for how such diluted potions can affect anything, it would be unreasonable for the scientific community to respond otherwise. Do "alternative" scientists really think that it would be reasonable to abandon hundreds of years of knowledge and experience, to give up all the established principles of chemistry, on the chance that someday someone might find a mechanism which explains how nothing affects something?

If and when the "alternative" scientist finds a plausible explanation for how actual or virtual non-existent molecules have an effect on the human body, the scientific community will have to alter its basic beliefs about chemistry. Until then, however, given the accomplishments of chemistry, it would be egregiously unreasonable to throw it all away in the hopes that there really is a mysterious force in the universe by which homeopathy and all chemical processes work.

the conspiracy theory and the bias of science
red herrings

Because scientists almost instinctively reject studies, no matter how well-designed they seem to be, that provide supportive evidence for "alternative" scientific notions, people like Milton argue that there is a conspiracy in the scientific community to stifle the truth. They also argue that the scientific community is so blind and biased that they refuse to consider evidence that upsets their pet beliefs. These two approaches seem to me contradictory rather than complementary. Either scientists know the "alternative" scientists are on to something, so they conspire to stifle them, or the scientists are just biased and bigoted. In any case, Milton reverts to attempts at "censorship" by defenders of science as the evidence for both claims.

Much of what Milton considers to be attempts at censorship have nothing to do with censorship at all. He raises issues that are red herrings, e.g., legitimate criticism of the media for promoting junk science in programs such as the Mysterious Origins of Man and cases of scientists who are paranoid about their research or who have been ostracized by colleagues for their weird ideas.

Milton seems to have a naive view of open-mindedness. He calls CSICOP the Paradigm Police and takes a dim view of anyone who criticizes, boycotts, protests, etc. the promotion of junk science. He seems to think that what is true in politics ought to be true in science. We should have laissez faire science and let the most popular view win out. Milton seems to think that we should determine scientific truth by public vote. He sees no harm in letting pass egregious abuses of science (such as Mysterious Origins of Man) and monstrous falsehoods (such as, there is no proof for evolution, which is just a theory) in the name of "free speech." To rebel against the bunk promulgated by the mass media, school boards, etc., is, in Milton's view, a type of oppression.

Even if some scientists call for banning a network from the airwaves for promoting pseudoscience, there is no systematic attempt to censor weird ideas by any scientific organization. There is no persecution of pseudoscientists, no burning at the stake, no secret cabal blackballing those with new notions about the nature of reality. There is a requirement that ideas that challenge fundamental ideas in any science prove their worth. When they do, they will bump out the old ideas. Witness what has happened recently in American archaeology with regard to Clovis and pre-Clovis human settlements. Scientists who were on the outside, ridiculed by their peers, ostracized, etc., for their ideas about pre-Clovis inhabitants are gradually getting a strong hearing. Why? Because they are delivering the goods, i.e., piling up the evidence. The scientists Milton weeps for are not delivering the goods. If and when they do, like Wegener, like Albert Goodyear, they will prevail.

arguments from ignorance

Another common error Milton makes is to argue that something is true (such as clairvoyance) because a bad argument was given to show that it is false. The argumentum ad ignorantiam can be found at several places on Milton's pages, but I will focus on just one. Milton defends the significance of unrelated coincidences such as dreaming of an airplane crash in a foreign country and waking to find that the news is reporting that there was an airplane crash in a foreign country. His defense is built on showing that a parapsychologist, Dr. Richard Wiseman, gave a false but persuasive explanation of such coincidences as being expected by the laws of probability.

First, Wiseman's argument is not very persuasive and I wonder if Milton is being disingenuous here. Second, no matter how many bad arguments against clairvoyance Milton can produce, they are irrelevant to whether there is any good positive evidence for such a thing. Wiseman's argument, as presented by Milton, claims that there are so many air crashes every day that dreaming of one would be very likely to coincide with an actual air disaster. A better explanation would be that fear of airplane crashes is widespread and the number of people who dream of such things every night is probably very great, so on any given night it is highly probable that there is at least one person of the six billion on the planet who dreams of an air disaster in a foreign country.

false labeling

Another common error Milton makes is to mislabel things. For example, he labels as pseudoscience Richard Dawkins analogy of the 'evolution' of biomorphs with the 'evolution' of living creatures. This misclassification exposes Milton's malevolence (if it is intentional and he knows this example has nothing to do with pseudoscience but he thinks it will help his anti-evolution cause) or his ignorance regarding pseudoscience. Milton may truly believe that Dawkin's analogy is a false analogy, but you might as well call nuclear physics a pseudoscience for having made an analogy between planets revolving around the sun and electrons revolving around the nucleus of an atom. A pseudoscience claims it is science when it is not. The distinguishing characteristic of pseudoscience is not logical error, nor is it empirical error. What distinguishes pseudoscience from science is that the former proposes theories which cannot be tested in any meaningful way, or if the theory can be tested, its adherents refuse to accept refuting evidence as valid. The pseudoscientist would rather reject hundreds of years of investigation, argument, theorizing, testing, revising, etc., than ever give up his or her belief, regardless of the evidence. So-called creation science is the paradigm of a pseudoscience. Pseudoscience is static and leads nowhere. It generates no fruitful discussion about the nature of things and produces nothing but dogmatists who will retain their views until the end of time. Science is dynamic and leads to all kinds of interesting discussions about the nature of things and produces a seemingly endless array of ideas and techniques, many of which supercede and supplant earlier ideas and techniques.

false dilemmas

Milton seems driven by a need to propose false dilemmas. The basic form of his argument goes like this:

> **Either we believe my side or we believe these liars, cheats, deceivers, frauds, pseudoscientists, false historians, conspirators, and dogmatists. Clearly, the second choice is unacceptable. Therefore, we should believe my side.**

Milton's approach reminds me of Arlen Specter's proposal to his colleagues during the Clarence Thomas hearings: Who do you believe? The distinguished gentleman or the slut? (Apologies to Dave Barry, whose created this caricature question that captures the essence of Specter's line of questioning.)

There are always third or fourth alternatives to Milton's proposals because he is so selective in his presentation of evidence and because he mixes legitimate criticism (e.g. of CSICOP and the Gauquelin affair, even though CSICOP turned out in the long run to be right about Gauquelin's data) with misunderstanding. He doesn't seem to have a clue as to what Carl Sagan meant by the following

> **We've arranged a global civilization in which the most crucial elements profoundly depend on science and technology. We have also arranged things so that almost no one understands science and technology. This is a prescription for disaster.** (from *The Demon-Haunted World: Science as a Candle in the Dark*)

Sagan was lamenting, as he had done many times before, the lack of communication between scientists and the public; the poor use of the mass media to convey what science is, does and has yet to do; and the inadequate job we are doing in educating our young people about the beauty and wonder of science. Milton thinks Sagan was claiming that science is an elitist affair, a claim Milton uses as a springboard to launch into his defense of eccentrics, crackpots and loners as the real heroes of science, the point of which is difficult to ascertain. It seems that he thinks that since some great scientists were crackpots, all crackpots are great scientists. Or, perhaps he means to argue that since some crackpots did good science, we should never close the door on any crackpot. However, if science opened the door and took seriously every crackpot idea that is proposed, nothing of worth would ever get done. The burden of proof is always on the crackpot, the new kid on the block, the one who wants to knock off hundreds of years of research, argument, theorizing, testing, etc., with a single dream. "I have a dream" might be a wonderful line in politics, but it has no intrinsic value in science.

It has been said that "Today's mighty oak is just yesterday's nut that held its ground." That's one way to look at it.

If you smash a nut with a hammer, nobody will give it any attention tomorrow. That's another way to look at it.

* * *

Richard Milton responds: At first, Milton responded with a little piece of disingenuous word juggling, distortion, and evasiveness with so little substance it was not worth responding to in detail. Either the man can't read or he intentionally twisted nearly every criticism I made of his work, save one (he's right about the DOE's stifling of research on cold fusion). He doesn't seem to see the difference between "exemplifies" or "seems to believe" with "says." He says he doesn't "favor ideas" and that "I present empirical evidence for consideration by my readers. (As I make abundantly clear, I am a reporter)." Since he does not say "I believe" this or that, his website should not be treated as if he were an advocate of the ideas he presents. When he labels something "Scientists and inventors who were ridiculed by science" we are supposed to read this as just a report by a reporter, noting a fact. We are not supposed to think that he might have some reason for the label or the selection of scientists he makes. Another label: "Taboo subjects. Investigate these and you're a crackpot." This label and these subjects are selected for no reason? What Milton does might be called "alternative" journalism.)

Then, he went whole hog and devoted an entire page on his website to debunking me and *The Skeptic's Dictionary*. Here, at least, he makes some substantive claims that I can respond to.

1. Milton writes that *Carroll is one of a growing band of non-scientists (he teaches philosophy) who believe they are qualified to tell us what we should and shouldn't believe, scientifically.*

   It is true that I am a non-scientist and that I teach philosophy. However, I don't tell anyone what to believe, about science or any other subject. I try to give reasons for *not* believing in certain things, like using acupuncture to unblock chi along a meridian in order to cure disease.

2. *That he has no scientific qualifications, or training, or professional experience, does not deter Carroll from his conviction that he is an authority on this subject and, in* The Skeptic's Dictionary*, he sets out to tell us ordinary people what we may and may not legitimately think.*

   It is true that I am not a scientist. (I hope Milton doesn't think you have to be a scientist to understand science.) I am a layperson who took physics, chemistry, and biology in college, who has read many books and magazines by scientists about science. I've even learned a few things from journalists (science writers for newspapers and magazines). I don't pretend to be a complete scientific illiterate who gets messages from Atlantis. I may not be qualified to comment on a claim about chemical bonding or dark matter, but I know enough about causality and properly designed experiments to recognize weaknesses in design or drawing conclusions not justified by the data. Even so, I don't tell anyone, ordinary or extraordinary, what they may legitimately think.

   As I say in the first lines of the introduction: "*The Skeptic's Dictionary* provides definitions, arguments, and essays on subjects supernatural, occult, paranormal, and pseudoscientific. I use the term "occult" to refer to any and all of these subjects. The reader is forewarned that *The Skeptic's Dictionary* does not try to present a balanced account of occult

subjects....Another purpose of *The Skeptic's Dictionary* is to provide references to the best skeptical materials on whatever topic is covered....[T]he one group that this book is not designed for is that of the true believers. My studies have convinced me that arguments or data critical of their beliefs are always considered by the true believer to be insignificant, irrelevant, manipulative, deceptive, not authoritative, unscientific, unfair, biased, closed-minded, irrational, and/or diabolical." Richard Milton's criticisms of my work support this last claim.

3. *This bogus-guru stance should be warning enough of what is to follow but, once he warms to his subject, Carroll's inhibitions disappear completely and he veers from the dogmatic to the preposterous in a hilarious display of scientific ignorance and prejudice.*

   The first item I have listed in my FAQ is the following:

   Q. Who made you God? [or, Who made you a bogus-guru?]

   A. I suppose you mean what gives me the right to question beliefs thousands of years old held by millions of people. You may think it arrogant and unbecoming to challenge cherished beliefs, especially since many of those who hold these beliefs are much wiser and more intelligent than I am. The alternatives are either to accept matters on faith without thinking about them or to think and critically examine things only until they begin to conflict with established beliefs and at that point assume I don't know what I am doing. Neither alternative appeals to me.

   I try to understand the limitations of the human mind and base my beliefs on the best evidence available, using the best methods of inquiry available, carefully considering the best arguments. All my beliefs are tentative even though I consider them more likely to be true than false.

   I have no preconceived notions about what should be true or false nor do I begin with a creed and set out to defend it. Like all humans, I am fallible. I prefer to have my errors corrected, however, rather than defend them in perpetuity.

   . . .

   Anyway, here are Milton's examples of my "hilarious display of scientific ignorance and prejudice:

4. *Carroll says; "Scientific research . . . has failed to demonstrate that acupuncture is effective against any disease."*

   Except for the scientific research that has demonstrated acupuncture is effective against some diseases and was published in peer-reviewed scientific journals more than a decade ago, such as Dundee, J.W., 1988, in Journal of the Royal Society of Medicine, *Dundee, J.W., 1987, in* British Journal of Anaesthesia, *59, p 1322. And Fry, E.N.S., 1986, in* Anaesthesia*, 41: 661-2.*

   Had Carroll made even the slightest attempt to search the scientific literature he would have found these and many other references to well-conducted double-blind trials in which patients experienced measurable benefits in comparison with the placebo group.

   If Milton had read the first three sentences in my article on acupuncture he would have read: "Acupuncture is a traditional Chinese medical technique for unblocking chi (ch'i or qi) by inserting needles at particular points on the body to balance the opposing forces of yin and yang. Chi is an energy that allegedly permeates all things. It is believed to flow through the body along 14 main pathways called meridians. " None of the studies he mentions--nor any others, for that matter--show that sticking needles into points on the traditional Chinese meridians (which do not correspond to anything we know about the body) unblocks chi. Nor do any studies show that any disease is due to blocked chi that knocks yin and yang out of balance. *Yin, yang, chi,* and *meridian* are metaphysical concepts that have not been, and I doubt ever could be, tested by science.

   Milton knows that I am well aware that sticking needles into people has physiological and psychological effects. So does giving people placebos or homeopathic remedies. It may seem like a fine point to Milton, but I maintain that sticking needles into people does not make what you are doing *traditional Chinese acupuncture*. Unless you are unblocking chi and making possible a balance of yin and yang, you are not performing acupuncture.

5. *Cryptozoology*

   The Skeptic's Dictionary *tells us that; "Since cryptozoologists spend most of their energy trying to establish the existence of creatures, rather than examining actual animals, they are more akin to psi researchers than to zoologists. Expertise in zoology, however, is asserted to be a necessity for work in cryptozoology,* *according to Dr. Bernard Heuvelmans, who coined the term . . ."*

Had he read Dr Heuvelmans' book, Carroll would have learned that the discovery of new species is normal science and many are discovered each year. New species number hundreds amongst insects, and dozens among small mammals and reptiles. Discovery of large unknown mammals and reptiles is unusual but certainly not unknown or even rare.

In 2002, for example, respected primatologist Dr Shelly Williams of the prestigious Jane Goodall Institute in Maryland, tracked and came face to face with a previously unknown species of great ape at Bili in the Congo, deep in the African jungle. The creatures stand some 6 feet tall and weigh up to 225 pounds. Dr Williams reported in New Scientist, *"Four suddenly came rushing out of the bush towards me. These guys were huge and they were coming in for the kill. As soon as they saw my face, they stopped and disappeared."*

I have no idea what his gripe is here. Is he trying to claim that Jane Goodall or anyone who discovers a new species is a cryptozoologist? Or that I am unaware that new species are still being discovered? You don't have to read Heuvelman's book to know that. A newspaper will do.

Milton seems to have misunderstood my point in comparing cryptozoologists to psi researchers. Let me try to clarify it. Both cryptozoologists and psi researchers spend there time trying to prove the existence of elusive phenomena: Bigfoot, ESP, the Loch Ness Monster, remote viewing, chupacabras, psychokinesis, and so on.

6. *Dermo-optical perception*

   Carroll says; "Dermo-optical perception (DOP) is the alleged ability to 'see' without using the eyes. DOP is a conjurer's trick, often involving elaborate blindfolding rituals, but always leaving a pathway (usually down the side of the nose), which allows for unobstructed vision."

   The scientific view; Dr Yvonne Duplessis was appointed director of a committee to investigate Dermo-optical sensitivity. Her conclusion is, 'Controlled studies indicate support for the theory of dermo-optical sensitivity and perception.' For details click here. [Unfortunately, the link Milton has-- http://www.creatic.fr/cic/B041Doc.htm-- is dead. I was able to find another source, however at http://www.sciencefrontieres.com/articles/dermo-optique.htm]

Dr Duplessis's experiments have even led to a possible perfectly natural explanation. In her conclusions, she says, 'Thus these different methods show that the thermal feelings induced by visible colors are not subjective, as it is generally admitted, and that the infrared radiations, situated in a far infrared range. are acting on every part of the body. This gives us possible grounds for concluding that also during ordinary visual perception of colored surfaces a human eye reacts not only to rays of the visible spectrum but also to infrared radiation emitted by these surfaces.'

More simply, Dr Duplessis's experiments appear to show that coloured surfaces reflect energy as heat as well as light and that the eye (like other parts of the human body) is to some extent sensitive to heat as well as to light -- a very much simpler explanation than Carroll's baseless inventions.

It is true that Duplessis claims to have evidence that humans can sense, with the skin, differences in thermal energy (i.e., heat) allegedly emitted as invisible radiations from different colors in the far infrared range. Milton calls her claims "the scientific view." However, Duplessis is just one in a long line of scientists who have made similar claims and have been discredited. This history is documented by Martin Gardner in his articles "Eyeless Vision" and "Dermo-optical Perception: A Peek Down the Nose." As in so many other cases of extraordinary claims backed by scientists who claim they could not possibly be duped, the DOP researchers have been duped time and time again. There have been two distinct DOP claims. One, and by far the more common, is the claim to be able to see words, images, colors, and so on while blindfolded. Whenever an expert in mentalism and deception is brought in to thwart all methods of peeking through the blindfold, the amazing DOP feats cease. The other claim involves being able to detect colors of objects hidden from sight. Some of these, like Duplessis, even invent the theory of thermal sensitivity of organs like the eyes or skin, to explain how the feat is achieved.

Duplessis's *Paranormal Perception of Colors* has been available in English since 1975. There is a reason we haven't seen a great surge in DOP performances by blindfolded or blind people over the past quarter of a century. If what she claims were in fact true and had been replicated and verified in other labs, the blind would now be living in colored environments where they had learned to "read" walls and halls, doors and floors, by different colors or colored lights. It didn't happen because Duplessis's theory has not been accepted by the scientific community. Perhaps it has not been accepted because of what is known about the amount of thermal energy given off by different colors on the same material and what is known about

the sensitivity of organs like the eye and skin. The likelihood that anyone has skin or an eye sensitive enough to pick up the small differences in thermal energy between say a blue and a red piece of cloth is near zero. Duplessis says she's proved this but the scientific community ignored her. Milton thinks she's right and the rest of the scientific world is wrong.

Gardner discusses several cases of people who were known for their ability to tell colors by touching things. In every case, when tests were done under controlled conditions where peeking was impossible, the subjects failed. In the cases where they succeeded, precautions were not taken to avoid cheating. Gardner even designed an aluminum box to put over the heads of such subjects for testing purposes, but few researchers seem to have used it, preferring their own sloppy protocols to any that might preclude cheating. If Milton thinks my claim that DOP feats are typically done by peeking is a "baseless invention," he should read Gardner's articles or read a book on conjuring or mentalism. Eyeless vision acts have been around for a long time.

7. *Extraterrestrials (UFOs, Flying Saucers)*

   Carroll says "Edward U. Condon was the head of a scientific research team which was contracted to the University of Colorado to examine the UFO issue. His report concluded that 'nothing has come from the study of UFOs in the past 21 years that has added to scientific knowledge...further extensive study of UFOs probably cannot be justified in the expectation that science will be advanced thereby'."

   Carroll adds, "So far . . . nothing has been positively identified as an alien spacecraft in a way required by common sense and science. That is, there has been no recurring identical UFO experience and there is no physical evidence in support of either a UFO flyby or landing."

   Had Carroll troubled to actually read Condon's report he would have found this conclusion regarding photographs identified by the report as 'Case 47';

   'This is one of the few UFO reports in which all factors investigated, geometric, psychological, and physical appear to be consistent with the assertion that an extraordinary flying object, silvery, metallic, disk-shaped, tens of meters in diameter, and evidently artificial, flew within sight of two witnesses.'

   It is perfectly true that Edward Condon concluded that 'further *extensive study of UFOs probably cannot be justified' but the reason he gave is that it is not possible to study fruitfully a phenomenon that occurs at random. He and his team emphatically did NOT conclude that "there is no physical evidence in support of either a UFO flyby or landing" - that is the conclusion of Carroll alone, and it is based purely on ignorance of the real facts as stated in Dr Condon's report.*

Case 47 refers to a movie of a sighting at Great Falls, Montana (lat. 47° 30' and long. 111° 18') on August 15, 1950. Click here to see a frame from this movie. Here is an abstract of this positive ID of a UFO:

"Witness I, general manager of a Great Falls baseball team, and Witness II, his secretary, observed two white lights moving slowly across the sky. Witness I made 16mm. motion pictures of the lights. Both individuals have recently reaffirmed the observation, and there is little reason to question its validity. The case remains unexplained. Analysis indicates that the images on the film are difficult to reconcile with aircraft or other known phenomena, although aircraft cannot be entirely ruled out. "

Milton meant to refer to case 46. For some reason, Milton left out the sentence prior to the one he quotes: "While it would be exaggerating to say that we have positively ruled out a fabrication, it appears significant that the simplest, most direct interpretation of the photographs confirms precisely what the witnesses said they saw. Yet, the fact that the object appears beneath the same part of the overhead wire in both photos can be used as an argument favoring a suspended model." Milton also left out the final sentence of the conclusion of the report on this case: "It cannot be said that the evidence positively rules out a fabrication, although there are some physical factors such as the accuracy of certain photometric measures of the original negatives which argue against a fabrication."

What was actually observed? "Witness I reportedly saw a metallic-looking, disk-shaped UPO. She called her husband, they located their camera, and he took photographs of the object before it disappeared in the distance." This occurred about 7:45 PM on May 11, 1950, in McMinnville, Oregon. The witnesses' testimony was taken 17 years after the event. The witnesses produced two photographs of the flying saucer. Photo 1. Photo 2. I leave it to the reader to peruse the entire account. Decide for yourself whether this is good physical evidence of a UFO flyby. Or has Milton's enthusiasm for the UFO hypothesis clouded his judgment once again?

8. *Carl Jung*

   Carroll says; "[Jung's] notion of synchronicity is that there is an acausal principle that links events having a similar meaning by their coincidence in time rather than sequentially. . . What evidence is there for synchronicity? None."

   Carroll carefully neglects to mention that the theory of synchronicity was proposed not by Jung alone but jointly with Wolfgang Pauli, who was Professor of Theoretical Physics at Princeton, a member of Niels Bohr's team that laid the foundations of Quantum Theory and who won the Nobel Prize in Physics in 1945. There thus exists a reasonable probability that the originator of synchronicity theory knew somewhat more about science than Carroll does. Asking 'what evidence is there?' for an explanatory theory that has been advanced specifically to account for previously unexplained evidence is a question even Homer Simpson would blush to ask.

   Sometimes, even those who ridicule you and stoop to ad hominem attacks are right about some things. Milton correctly suggests that asking for evidence for an explanation is at best the wrong question. At worst it is a category mistake. I should be asking for evidence of the *explicandum* (the thing to be explained), not the *explanans* (what does the explaining). I have rewritten two sentences in the Jung entry to fix this problem.

   "What reasons are there for accepting synchronicity as an explanation for anything in the real world? What it explains is more simply and elegantly explained by the ability of the human mind to find meaning and significance where there is none (apophenia)."

9. Occult statistics

   Carroll says; "Legions of parapsychologists, led by such generals as Charles Tart and Dean Radin, have also appealed to statistical anomalies as proof of ESP." But, "Skeptics are unimpressed with occult statistics that assert improbabilities for what has already happened."

   Carroll's scientific illiteracy finally comes out into the open here. Even his fellow 'skeptics' in CSICOP would hesitate to assert that science may only cite statistics on probability in connection with events that have not yet happened!

   Probability theory deals with the mathematical calculation of the *chances of an event taking place -- regardless of whether the event has taken place or not. The probability that a tossed coin will land heads is 50-50 or P=0.5. This is as true for a coin that has already been tossed as it is for one yet to be tossed. If someone were to toss 100 heads in a row having declared in advance their intention to make this happen, then the odds against such a series happening normally are so high as to merit scientific investigation to attempt to determine a cause other than chance.*

In the case of the experiments reported by Dean Radin in the respected physics journal Foundations of Physics, the odds against the results obtained in the Princeton Engineering Laboratory coming about by chance alone are one in 10 to the power of 35 (1 in 1035).

For Carroll to ignore improbabilities of this magnitude is not being "skeptical" -- it is being in denial.

The two quotes cited by Milton at the top of this comment are juxtaposed to make them appear to be related to one another. In the article, I think it is clear that when I bring up the point about being dazzled about improbabilities regarding what has already happened, I am referring to arguments regarding the need for a designer of the universe based on some theoretical notion of odds of the genetic code happening by chance or odds of the various parts of the solar system, galaxy, or universe coming together by chance.

Radin, Charles Honorton, Robert Jahn, Gary Schwartz, and others of like ilk are fond of asserting things about odds being a trillion to one against chance. Such claims impress people like Milton. I have written about Jahn's claims in my entry on the PEAR experiments.

In 1987, Dean Radin and Nelson did a meta-analysis of all RNG experiments done between 1959 and 1987 and found that they produced odds against chance beyond a trillion to one (Radin 1997: 140). This sounds impressive, but as Radin says "in terms of a 50% hit rate, the overall experimental effect, calculated per study, was about 51 percent, where 50 percent would be expected by chance" [emphasis added] (141). A couple of sentences later, Radin gives a more precise rendering of "about 51 percent" by noting that the overall effect was "just under 51 percent." Similar results were found with experiments where people tried to use their minds to affect the outcome of rolls of the dice, according to Radin. And, when Nelson did his own analysis of all the PEAR data (1,262 experiments involving 108 people), he found similar results to the earlier RNG studies but "with odds against chance of four

thousand to one" (Radin 1997: 143). Nelson also claimed that there were no "star" performers.

However, according to Ray Hyman, “the percentage of hits in the intended direction was only 50.02% (Hyman 1989: 152)” in the PEAR studies. And one ‘operator’ (the term used to describe the subjects in these studies) was responsible for 23% of the total data base. His hit rate was 50.05%. Take out this operator and the hit rate becomes 50.01%. According to John McCrone, "Operator 10," believed to be a PEAR staff member, "has been involved in 15% of the 14 million trials, yet contributed to a full half of the total excess hits" (McCrone 1994). According to Dean Radin, the criticism that there "was any one person responsible for the overall results of the experiment...was tested and found to be groundless" (Radin 1997, 221). His source for this claim is a 1991 article by Jahn et al. in the Journal of Scientific Exploration, "Count population profiles in engineering anomalies experiments" (5:205-32). However, Jahn gives the data for his experiments in Margins of Reality: The Role of Consciousness in the Physical World (Harcourt Brace, 1988, p. 352-353). McCrone has done the calculations and found that 'If [operator 10's] figures are taken out of the data pool, scoring in the "low intention" condition falls to chance while "high intention" scoring drops close to the .05 boundary considered weakly significant in scientific results."

The bottom line is that *statistical significance* is not equivalent to *meaningful* or *important*.

10. **Remote viewing**

Carroll says; "The CIA and the U.S. Army thought enough of remote viewing to spend millions of taxpayers' dollars on research in a program referred to as 'Stargate'."

Carroll scorns such trials because of the inaccuracy of some statements made by the subjects but, scientifically, the question is not how consistently accurate is remote viewing, but does it exist at all? There is unequivocal evidence that it does.

A recently declassified CIA document details a remarkably accurate example, under controlled conditions, of remote viewing of a top secret Russian base by Pat Price in 1974. To read details of this project Click Here. Although Price made a lot of incorrect guesses about the target he was able to produce, with startling accuracy, engineering grade drawings of a unique 150-foot high gantry crane with six foot high wheels running into an *underground entrance. The existence of this massive structure, exactly as described, was later confirmed through satellite photography.*

It's true there is a document in which somebody is dazzled by Pat Price's description of a crane. To Milton, this counts as "unequivocal evidence" for remote viewing.

I don't scorn the waste of more than 20 million tax dollars on Stargate on the grounds that there were inaccurate statements made by remote viewers. Of the thousands of statements made, it would be odd if many of them couldn't be made to fit many scenarios and be deemed "accurate" by Milton or the CIA. I scorn the experiment because the idea that humans are clairvoyant ("remote viewing" is just a fancy expression for clairvoyance) or telepathic has been tested for more than 150 years and, in the words of Milbourne Christopher "…many brilliant men have investigated the subject…and they have yet to find a single person who can, without trickery, receive even the simplest three-letter word under test conditions."

11. Spontaneous Human Combustion

Carroll says; "While no one has ever witnessed SHC, several deaths involving fire have been attributed to SHC by investigators and storytellers."

The slightest research would have revealed to Carroll that many cases of possible SHC were independently witnessed by reliable people. In some cases, the victims themselves survived to tell about their experiences. Six survival cases are described in detail Here.

Cases include London Fire Brigade Commander John Stacey and his fire crew who reached the scene of a burning man within 5 minutes of receiving a emergency call, and the case of Agnes Phillips who burst into flames in a parked car in a Sydney suburb in 1998 and was pulled out by a passer-by.

The research Milton thinks I should have done is in the book *Ablaze!: The Mysterious Fires of Spontaneous Human Combustion* by Larry E. Arnold, a book which features a blurb from Maury Povich on its back cover. [Joe Nickell refers to this work as *Spontaneous Human Nonsense*.]

The stories that Milton posts on his web site reveal his willingness to be dazzled by speculations about SHC. It is true that the examples he has chosen can't be explained by the wick effect because they are all of cases where the person in flames

is come upon within a relatively short time of being on fire. The wick effect requires hours of slow burning. However, the evidence that any of these cases is actually a case of spontaneous human combustion is flimsy at best. As Milton says: "None of these cases is conclusive evidence for the existence of 'Spontaneous Human Combustion'."

Many more similar examples of ignorance and prejudice could be quoted from The Skeptic's Dictionary*, but would serve little purpose. It is already abundantly clear that Carroll's book is no dictionary but a private agenda, and that he himself is no skeptic but a knee-jerk reactionary to the new, the unexpected, the ambiguous and the anomalous.*

My agenda is set forth in the first few lines of the introduction to my book. I am skeptical of the kinds of things Milton accepts and I set out to provide the best skeptical arguments on those topics with references to the best skeptical literature I'm aware of. Nothing more, nothing less.

Robert Todd Carroll is a perfect example of the reason for this site's existence. Some academic professionals who are meticulously careful of fact in their normal professional life, suddenly throw off all reasoned restraint when it comes to so-called "debunking" of what they consider to be new age nonsense and feel justified in making as many careless and inaccurate statements as they please because they mistakenly imagine they are defending science against weirdos.

I can't speak for other skeptics, but I do not believe Milton or others who believe in the paranormal, the supernatural, or the occult are "weirdos." Nor do I think that believers are unintelligent. Many of them are obviously very intelligent, much more intelligent than I am. But being more intelligent than someone else doesn't make one right. I simply think Milton is wrong about many things and his arguments are defective.

The reality is that their irrational reaction arises from their own inability to deal scientifically with the new and ambivalent, even when (as in the case of dermo-optical perception) there is probably a simple natural explanation, or when (as in the case of the new Congo primate) it is simply unexpected and previously unknown to science.

Milton can try to rationalize our disagreements with him by proposing that we suffer from some sort of mental defect, but the fact is that the skeptics I read and admire try to offer good reasons for their beliefs and their disbeliefs. Whatever is

motivating them is irrelevant to whether their arguments and explanations are cogent.

This book is a stark warning to every student of science, logic and philosophy of what can happen when an otherwise rational person goes off on a personal crusade motivated by his own self-deluding prejudices.

The same might be said of Milton's Alternative Science pages.

more Internet Bunk

- The Millennium Group - Science in the Service of Humanity
- Joe Firmage & The Truth
- Pharaoh's Pump Foundation
- The Junk Science Page

The evolutionary future of man - A biological view of progress

Dawkins, Richard, The evolutionary future of man.., Vol. 328, Economist, 09-11-1993, pp 87.

EVOLUTION is widely regarded as a progressive force thrusting inexorably towards racial improvement, which may be seen as offering some tangible hope for our troubled species. Unfortunately this way of thinking is based on two misunderstandings. First, it is by no means clear that evolution is necessarily progressive. Second, even when it is progressive, significant change proceeds on a time-scale many orders of magnitude longer than the scale of tens or hundreds of years with which historians feel at home.

We can define evolutionary progress either in a value-laden or a value-neutral way--ie, either with or without building in notions of what is good or bad. A value-laden definition specifies whether the factor being monitored, be it brain-size, intelligence, artistic ability, physical strength or whatever, is desirable or undesirable. If a desirable factor increases, that is progress. But on a value-neutral definition, any change at all counts as progress, just so long as it continues on its course. Such a definition simply takes three entities in a time sequence--think of them as a series of ancestral fossils and call them Early, Middle and Late- -and asks whether the change from Early to Middle is in the same direction as the change from Middle to Late. If the answer is yes, that is a progressive change. This definition is value-neutral because the factor which we discover to be "progressive" could be something which we regard as bad--say, idleness or stupidity. In this value-neutral sense, a continued trend towards decreased brain size would be progressive, just as much as a trend towards increased brain size would be. The only thing that would not be progressive would be a reversal of the trend.

It was once fashionable for biologists to believe in something called orthogenesis. This was the theory that trends in evolution constitute a driving force and continue under their own momentum. The Irish Elk was thought to have been driven extinct by its huge antlers, which in turn were thought to have grown bigger under the influence of an orthogenetic force. Perhaps initially there was some advantage in larger antlers and this was how the trend started. But, once started, the trend had its own internal unstoppability, and, as the generations went by, the antlers continued inexorably to grow until they drove the species extinct.

We now think that the theory of orthogenesis is wrong. If a trend is seen towards increasing antler size, this is because natural selection favours larger antlers. Individual stags with large antlers have more offspring than stags with average-sized antlers, either because they survive better (unlikely) or attract females (probably irrelevant) or because they are better at intimidating rivals (likely). If the trend appears to persist for a long time in the fossil record, this indicates that natural selection was pushing in that direction for all that time. Metaphors like "inherent force" and "inexorable momentum" have no validity.

It seems to follow that there is no general reason to expect evolution to be progressive--even in the weak, value-neutral sense. There will be times when increased size of some organ is favoured and other times when decreased size is favoured. Most of the time, average-sized individuals will be favoured in the population and both extremes will be penalised. During these times the population exhibits evolutionary stasis (ie, no change) with respect to the factor being measured. If we had a complete fossil record and looked for trends in some particular dimension, such as leg length, we would expect to see periods of no change alternating with fitful continuations or reversals in direction--like a weathervane in changeable, gusty weather.

It is all the more intriguing to find that sometimes long, progressive trends in one direction do turn up. When an organ is used for intimidation (like a stag's antlers) or for attraction (like the peacock's tail), it may be that the best size to have--from the point of view of intimidation or attraction--is always slightly larger than the average in the population. Even when the average gets bigger, the optimum is always one step ahead. It is possible that such "moving-target selection" did drive the Irish Elk extinct after all: by pushing the "intimidation optimum" too far ahead of what would have been the overall "utilitarian optimum". Peacocks and male birds of paradise also seem to have been pushed, in this case by female-taste selection, far from the utilitarian optimum of an efficient flying and surviving machine (though they have not been driven over the edge into extinction).

Another force driving progressive evolution is the so-called "arms- race". Prey animals evolve faster running speeds because predators do. Consequently predators have to evolve even faster running speeds, and so on, in an escalating spiral. Such arms races probably account for the spectacularly advanced engineering of eyes, ears, brains, bat "radar" and all the other high-tech weaponry that animals display. Arms races are a special case of "co-evolution". Co-evolution occurs whenever the environment in which creatures evolve is itself evolving. From an antelope's point of view, lions are part of the environment like the weather--with the important difference that lions evolve.

Virtual progress

I want to suggest a new kind of co-evolution which, I believe, may have been responsible for one of the most spectacular examples of progressive evolution: the enlargement of the human brain. At some point in the evolution of brains, they acquired the ability to simulate models of the outside world. In its advanced forms we call this ability "imagination. " It may be compared to the virtual-reality software that runs on some computers. Now here is the point I want to make. The internal "virtual world" in which animals live may in effect become a part of the environment, of comparable importance to the climate, vegetation, predators and so on outside. If so, a co-evolutionary spiral may take off, with hardware--especially brain hardware--evolving to meet improvements in the internal "virtual environment." The changes in hardware then stimulate improvements in the virtual environment, and the spiral continues.

The progressive spiral is likely to advance even faster if the virtual environment is put together as a shared enterprise involving many individuals. And it is likely to reach breakneck speeds if it can accumulate progressively over generations. Language and other aspects of human culture provide a mechanism whereby such accumulation can occur. It may be that brain hardware has co-evolved with the internal virtual worlds that it creates. This can be called hardware-software co-evolution. Language could be both a vehicle of this co-evolution and its most spectacular software product. We know almost nothing of how language originated, since it started to fossilise only very recently, in the form of writing. Hardware has been fossilising for much longer--at least the brain's bony outer casing has. Its steadily increasing size, indicating a corresponding increase in the size of the brain itself, is what I want to turn to next.

It is almost certain that modern Homo sapiens (which dates only from about 100,000 years ago) is descended from a similar species, H. erectus, which first appeared a little before 1.6m years ago. It is thought that H. erectus, in turn, was descended from some form of Australopithecus. A possible candidate which lived about 3m years ago is Australopithecus afarensis, represented by the famous "Lucy." These creatures, which are often described as upright-walking apes, had brains about the size of a chimpanzee's. Figure 1 on the next page shows pictures of the three skulls, in chronological order. Presumably the change from Australopithecus to erectus was gradual. This is not to say that it took 1.5m years to accomplish at a uniform rate. It could easily have occurred in fits and starts. The same goes for the change from erectus to sapiens. By about 300,000 years ago, we start to find fossils that are called "archaic H. sapiens", largish-brained people like ourselves but with heavy brow ridges more like H. erectus.

It looks, in a general way, as though there are some progressive changes running through this series. Our braincase is nearly twice the size of erectus's; and erectus's braincase, in turn, is about twice the size of that of Australopithecus afarensis. This impression is vividly illustrated in the next picture, which was prepared using a program called Morph.*

To use Morph, you supply it with a starting picture and an ending picture, and tell it which points on the starting picture correspond to which opposite-number points on the ending picture. Morph then computes a series of mathematical intermediates between the two pictures. The series may be viewed as a cine film on the computer screen, but for printing it is necessary to extract a series of still frames--arranged here in order in a spiral (figure 2). The spiral includes two concatenated sequences: Australopithecus to H. erectus and H. erectus to H. sapiens. Conveniently the two time intervals separating these three landmark fossils are approximately the same, about 1.5m years. The three labelled landmark skulls constitute the data supplied to Morph. All the others are the computed intermediates (ignore H. futuris for the moment).

Swirl your eye round the spiral looking for trends. It is broadly true that any trends you find before H. erectus continue after him. The film version shows this much more dramatically, so much so that it is hard, as you watch the film, to detect any discontinuity as you pass through H. erectus. We have made similar films for a number of probable evolutionary transitions in human ancestry. More often than not, trends show reversals of direction. The relatively smooth continuity around H. erectus is quite unusual.

We can say that there has been a long, progressive--and by evolutionary standards very rapid--trend over the past 3m years of human skull evolution. I am speaking of progress in the value-neutral sense here. As it happens, anybody who thinks increased brain size has positive value can also claim this trend as value-laden progress too. This is because the dominant trend, flowing both before and after H. erectus, is the spectacular ballooning of the brain.

What of the future? Can we extrapolate the trend from H. erectus through and beyond H. sapiens, and predict the skull shape of H. futuris 3m years hence? Only an orthogeneticist would take it seriously; but, for what it is worth, we have made an extrapolation with the aid of Morph, and it is appended at the end of the spiral diagram. It shows a continuation of the trend to inflate the balloon of the braincase; the chin continues to move forward and sharpen into a silly little goatee point, while the jaw itself looks too small to chew anything but baby pap. Indeed the whole cranium is quite reminiscent of a baby's skull. It was long ago suggested that human evolution is an example of "paedomorphosis": the retention of juvenile characteristics into adulthood. The adult human skull looks more like a baby chimp's than like an adult chimp's.

Don't bank on H. futuris

Is there any likelihood that something like this hypothetical large- brained H. futuris will evolve? I'd put very little money on it, one way or the other. Certainly the mere fact that brain inflation has been the dominant trend over the past 3m years says almost nothing about probable trends in the next 3m. Brains will continue to inflate only if natural selection continues to favour large-brained individuals. This means, when you come down to it, if large-brained individuals manage to have, on average, more children than small-brained ones.

It is not unreasonable to assume that large brains go with intelligence, and that intelligence, in our wild ancestors, was associated with ability to survive, ability to attract mates or ability to outwit rivals. Not unreasonable--but both these clauses would find their critics. It is an article of passionate faith among "politically correct" biologists and anthropologists that brain size has no connection with intelligence; that intelligence has nothing to do with genes; and that genes are probably nasty fascist things anyway.

Leaving this to one side, problems with the idea remain. In the days when most individuals died young, the main qualification for reproduction was survival into adulthood. But in our western civilisation few die young, most adults choose to have fewer children than they are physically and economically capable of, and it is by no means clear that people with the largest families are the most intelligent. Anybody viewing future human evolution from the perspective of advanced western civilisation is unlikely to make confident predictions about brain size continuing to evolve.

In any case, all these ways of viewing the matter are far too short- term. Socially important phenomena such as contraception and education exert their influences over the timescale of human historians, over decades and centuries. Evolutionary trends--at least those that last long enough to deserve the title progressive--are so slow that they are all but totally insensitive to the vagaries of social and historical time. If we could assume that something like our advanced scientific civilisation was going to last for 1m, or even 100,000, years, it might be worth thinking about the undercurrents of natural-selection pressure in these civilised conditions. But the likelihood is that, in 100,000 years time, we shall either have reverted to wild barbarism, or else civilisation will have advanced beyond all recognition--into colonies in outer space, for instance. In either case, evolutionary extrapolations from present conditions are likely to be highly misleading.

Evolutionists are usually pretty coy about predicting the future. Our species is a particularly hard one to predict because human culture, at least for the past few thousand years and speeding up all the time, changes in ways that mimic evolutionary change, only thousands to hundreds of thousands of times faster. This is most clearly seen when we look at technical hardware. It is almost a cliche to point out that the wheeled vehicle, the aeroplane, and the electronic computer, to say nothing of more frivolous examples such as dress fashions, evolve in ways strikingly reminiscent of biological evolution. My formal definitions of value-laden and value-neutral progress, although designed for fossil bones, can be applied, without modification, to cultural and technological trends.

Prevailing skirt and hair lengths in western society are progressive--value-neutrally, because they are too trivial to be anything else--for short periods if at all. Viewed over the timescale of decades, the average lengths fritter up and down like yo-yos. Weapons improve (at what they are designed to do, which may be of positive or negative value depending on your point of view) consistently and progressively, at least partly to counter improvements in the weaponry of enemies. But mostly, like any other technology, they improve because new inventions build on earlier ones and inventors in any age benefit from the ideas, efforts and experience of their predecessors. This principle is most spectacularly demonstrated by the evolution of the digital computer. The late Christopher Evans, a psychologist and author, calculated that if the motor car had evolved as fast as the computer, and over the same time period, "Today you would be able to buy a Rolls-Royce for ?.35, it would do three million miles to the gallon, and it would deliver enough power to drive the QE2. And if you were interested in miniaturisation, you could place half a dozen of them on a pinhead."

Science and the technology that it inspires can, of course, be used for backward ends. Continued trends in, say, aeroplane or computer speed, are undoubtedly progressive in a value-neutral sense. It would be easy to see them also as progressive in various value-laden senses. But such progress could also turn out to be laden with deeply negative value if the technologies fall into the hands of, say, religious fundamentalists bent on the destruction of rival sects who face a different point of the compass in order to pray, or some equally insufferable habit. Much may depend on whether the societies with the scientific know-how and the civilised values necessary to develop the technologies keep control of them; or whether they allow them to spread to educationally and scientifically backward societies which happen to have the money to buy them.

Scientific and technological progress themselves are value-neutral. They are just very good at doing what they do. If you want to do selfish, greedy, intolerant and violent things, scientific technology will provide you with by far the most efficient way of doing so. But if you want to do good, to solve the world's problems, to progress in the best value-laden sense, once again, there is no better means to those ends than the scientific way. For good or ill, I expect scientific knowledge and technical invention to develop progressively over the next 150 years, and at an accelerating rate.

The Improbability of God

by Richard Dawkins
The following article is from Free Inquiry magazine, Volume 18, Number 3.

Much of what people do is done in the name of God. Irishmen blow each other up in his name. Arabs blow themselves up in his name. Imams and ayatollahs oppress women in his name. Celibate popes and priests mess up people's sex lives in his name. Jewish shohets cut live animals' throats in his name. The achievements of religion in past history - bloody crusades, torturing inquisitions, mass-murdering conquistadors, culture-destroying missionaries, legally enforced resistance to each new piece of scientific truth until the last possible moment - are even more impressive. And what has it all been in aid of? I believe it is becoming increasingly clear that the answer is absolutely nothing at all. There is no reason for believing that any sort of gods exist and quite good reason for believing that they do not exist and never have. It has all been a gigantic waste of time and a waste of life. It would be a joke of cosmic proportions if it weren't so tragic.

Why do people believe in God? For most people the answer is still some version of the ancient Argument from Design. We look about us at the beauty and intricacy of the world - at the aerodynamic sweep of a swallow's wing, at the delicacy of flowers and of the butterflies that fertilize them, through a microscope at the teeming life in every drop of pond water, through a telescope at the crown of a giant redwood tree. We reflect on the electronic complexity and optical perfection of our own eyes that do the looking. If we have any imagination, these things drive us to a sense of awe and reverence. Moreover, we cannot fail to be struck by the obvious resemblance of living organs to the carefully planned designs of human engineers. The argument was most famously expressed in the watchmaker analogy of the eighteenth-century priest William Paley. Even if you didn't know what a watch was, the obviously designed character of its cogs and springs and of how they mesh together for a purpose would force you to conclude "that the watch must have had a maker: that there must have existed, at some time, and at some place or other, an artificer or artificers, who formed it for the purpose which we find it actually to answer; who comprehended its construction, and designed its use." If this is true of a comparatively simple watch, how much the more so is it true of the eye, ear, kidney, elbow joint, brain? These beautiful, complex, intricate, and obviously purpose-built structures must have had their own designer, their own watchmaker - God.

So ran Paley's argument, and it is an argument that nearly all thoughtful and sensitive people discover for themselves at some stage in their childhood. Throughout most of history it must have seemed utterly convincing, self-evidently true. And yet, as the result of one of the most astonishing intellectual revolutions in history, we now know that it is wrong, or at least superfluous. We now know that the order and apparent purposefulness of the living world has come about through an entirely different process, a process that works without the need for any designer and one that is a consequence of basically very simple laws of physics. This is the process of evolution by natural selection, discovered by Charles Darwin and, independently, by Alfred Russel Wallace.

What do all objects that look as if they must have had a designer have in common? The answer is statistical improbability. If we find a transparent pebble washed into the shape of a crude lens by the sea, we do not conclude that it must have been designed by an optician: the unaided laws of physics are capable of achieving this result; it is not too improbable to have just "happened." But if we find an elaborate compound lens, carefully corrected against spherical and chromatic aberration, coated against glare, and with "Carl Zeiss" engraved on the rim, we know that it could not have just happened by chance. If you take all the atoms of such a compound lens and throw them together at random under the jostling influence of the ordinary laws of physics in nature, it is theoretically possible that, by sheer luck, the atoms would just happen to fall into the pattern of a Zeiss compound lens, and even that the atoms round the rim should happen to fall in such a way that the name Carl Zeiss is etched out. But the number of other ways in which the atoms could, with equal likelihood, have fallen, is so hugely, vastly, immeasurably greater that we can completely discount the chance hypothesis. Chance is out of the question as an explanation.

This is not a circular argument, by the way. It might seem to be circular because, it could be said, any particular arrangement of atoms is, with hindsight, very improbable. As has been said before, when a ball lands on a particular blade of grass on the golf course, it would be foolish to exclaim: "Out of all the billions of blades of grass that it could have fallen on, the ball actually fell on this one. How amazingly, miraculously improbable!" The fallacy here, of course, is that the ball had to land somewhere. We can only stand amazed at the improbability of the actual event if we specify it a priori: for example, if a blindfolded man spins himself round on the tee, hits the ball at random, and achieves a hole in one. That would be truly amazing, because the target destination of the ball is specified in advance.

Of all the trillions of different ways of putting together the atoms of a telescope, only a minority would actually work in some useful way. Only a tiny minority would have Carl Zeiss engraved on them, or, indeed, any recognizable words of any human language. The same goes for the parts of a watch: of all the billions of possible ways of putting them together, only a tiny minority will tell the time or do anything useful. And of course the same goes, a fortiori, for the parts of a living body. Of all the trillions of trillions of ways of putting together the parts of a body, only an infinitesimal minority would live, seek food, eat, and reproduce. True, there are many different ways of being alive - at least ten million different ways if we count the number of distinct species alive today - but, however many ways there may be of being alive, it is certain that there are vastly more ways of being dead!

We can safely conclude that living bodies are billions of times too complicated - too statistically improbable - to have come into being by sheer chance. How, then, did they come into being? The answer is that chance enters into the story, but not a single, monolithic act of chance. Instead, a whole series of tiny chance steps, each one small enough to be a believable product of its predecessor, occurred one after the other in sequence. These small steps of chance are caused by genetic mutations, random changes - mistakes really - in the genetic material. They give rise to changes in the existing bodily structure. Most of these changes are deleterious and lead to death. A minority of them turn out to be slight improvements, leading to increased survival and reproduction. By this process of natural selection, those random changes that turn out to be beneficial eventually spread through the species and become the norm. The stage is now set for the next small change in the evolutionary process. After, say, a thousand of these small changes in series, each change providing the basis for the next, the end result has become, by a process of accumulation, far too complex to have come about in a single act of chance.

For instance, it is theoretically possible for an eye to spring into being, in a single lucky step, from nothing: from bare skin, let's say. It is theoretically possible in the sense that a recipe could be written out in the form of a large number of mutations. If all these mutations happened simultaneously, a complete eye could, indeed, spring from nothing. But although it is theoretically possible, it is in practice inconceivable. The quantity of luck involved is much too large. The "correct" recipe involves changes in a huge number of genes simultaneously. The correct recipe is one particular combination of changes out of trillions of equally probable combinations of chances. We can certainly rule out such a miraculous coincidence. But it is perfectly plausible that the modern eye could have sprung from something almost the same as the modern eye but not quite: a very slightly less elaborate eye. By the same argument, this slightly less elaborate eye sprang from a slightly less elaborate eye still, and so on. If you assume a sufficiently large number of sufficiently small differences between each evolutionary stage and its predecessor, you are bound to be able to derive a full, complex, working eye from bare skin. How many intermediate stages are we allowed to postulate? That depends on how much time we have to play with. Has there been enough time for eyes to evolve by little steps from nothing?

The fossils tell us that life has been evolving on Earth for more than 3,000 million years. It is almost impossible for the human mind to grasp such an immensity of time. We, naturally and mercifully, tend to see our own expected lifetime as a fairly long time, but we can't expect to live even one century. It is 2,000 years since Jesus lived, a time span long enough to blur the distinction between history and myth. Can you imagine a million such periods laid end to end? Suppose we wanted to write the whole history on a single long scroll. If we crammed all of Common Era history into one metre of scroll, how long would the pre-Common Era part of the scroll, back to the start of evolution, be? The answer is that the pre-Common Era part of the scroll would stretch from Milan to Moscow. Think of the implications of this for the quantity of evolutionary change that can be accommodated. All the domestic breeds of dogs - Pekingeses, poodles, spaniels, Saint Bernards, and Chihuahuas - have come from wolves in a time span measured in hundreds or at the most thousands of years: no more than two meters along the road from Milan to Moscow. Think of the quantity of change involved in going from a wolf to a Pekingese; now multiply that quantity of change by a million. When you look at it like that, it becomes easy to believe that an eye could have evolved from no eye by small degrees.

It remains necessary to satisfy ourselves that every one of the intermediates on the evolutionary route, say from bare skin to a modern eye, would have been favored by natural selection; would have been an improvement over its predecessor in the sequence or at least would have survived. It is no good proving to ourselves that there is theoretically a chain of almost perceptibly different intermediates leading to an eye if many of those intermediates would have died. It is sometimes argued that the parts of an eye have to be all there together or the eye won't work at all. Half an eye, the argument runs, is no better than no eye at all. You can't fly with half a wing; you can't hear with half an ear. Therefore there can't have been a series of step-by-step intermediates leading up to a modern eye, wing, or ear.

This type of argument is so naive that one can only wonder at the subconscious motives for wanting to believe it. It is obviously not true that half an eye is useless. Cataract sufferers who have had their lenses surgically removed cannot see very well without glasses, but they are still much better off than people with no eyes at all. Without a lens you can't focus a detailed image, but you can avoid bumping into obstacles and you could detect the looming shadow of a predator.

As for the argument that you can't fly with only half a wing, it is disproved by large numbers of very successful gliding animals, including mammals of many different kinds, lizards, frogs, snakes, and squids. Many different kinds of tree-dwelling animals have flaps of skin between their joints that really are fractional wings. If you fall out of a tree, any skin flap or flattening of the body that increases your surface area can save your life. And, however small or large your flaps may be, there must always be a critical height such that, if you fall from a tree of that height, your life would have been saved by just a little bit more surface area. Then, when your descendants have evolved that extra surface area, their lives would be saved by just a bit more still if they fell from trees of a slightly greater height. And so on by insensibly graded steps until, hundreds of generations later, we arrive at full wings.

Eyes and wings cannot spring into existence in a single step. That would be like having the almost infinite luck to hit upon the combination number that opens a large bank vault. But if you spun the dials of the lock at random, and every time you got a little bit closer to the lucky number the vault door creaked open another chink, you would soon have the door open! Essentially, that is the secret of how evolution by natural selection achieves what once seemed impossible. Things that cannot plausibly be derived from very different predecessors can plausibly be derived from only slightly different predecessors. Provided only that there is a sufficiently long series of such slightly different predecessors, you can derive anything from anything else.

Evolution, then, is theoretically capable of doing the job that, once upon a time, seemed to be the prerogative of God. But is there any evidence that evolution actually has happened? The answer is yes; the evidence is overwhelming. Millions of fossils are found in exactly the places and at exactly the depths that we should expect if evolution had happened. Not a single fossil has ever been found in any place where the evolution theory would not have expected it, although this could very easily have happened: a fossil mammal in rocks so old that fishes have not yet arrived, for instance, would be enough to disprove the evolution theory.

The patterns of distribution of living animals and plants on the continents and islands of the world is exactly what would be expected if they had evolved from common ancestors by slow, gradual degrees. The patterns of resemblance among animals and plants is exactly what we should expect if some were close cousins, and others more distant cousins to each other. The fact that the genetic code is the same in all living creatures overwhelmingly suggests that all are descended from one single ancestor. The evidence for evolution is so compelling that the only way to save the creation theory is to assume that God deliberately planted enormous quantities of evidence to make it look as if evolution had happened. In other words, the fossils, the geographical distribution of animals, and so on, are all one gigantic confidence trick. Does anybody want to worship a God capable of such trickery? It is surely far more reverent, as well as more scientifically sensible, to take the evidence at face value. All living creatures are cousins of one another, descended from one remote ancestor that lived more than 3,000 million years ago.

The Argument from Design, then, has been destroyed as a reason for believing in a God. Are there any other arguments? Some people believe in God because of what appears to them to be an inner revelation. Such revelations are not always edifying but they undoubtedly feel real to the individual concerned. Many inhabitants of lunatic asylums have an unshakable inner faith that they are Napoleon or, indeed, God himself. There is no doubting the power of such convictions for those that have them, but this is no reason for the rest of us to believe them. Indeed, since such beliefs are mutually contradictory, we can't believe them all.

There is a little more that needs to be said. Evolution by natural selection explains a lot, but it couldn't start from nothing. It couldn't have started until there was some kind of rudimentary reproduction and heredity. Modern heredity is based on the DNA code, which is itself too complicated to have sprung spontaneously into being by a single act of chance. This seems to mean that there must have been some earlier hereditary system, now disappeared, which was simple enough to have arisen by chance and the laws of chemistry and which provided the medium in which a primitive form of cumulative natural selection could get started. DNA was a later product of this earlier cumulative selection. Before this original kind of natural selection, there was a period when complex chemical compounds were built up from simpler ones and before that a period when the chemical elements were built up from simpler elements, following the well-understood laws of physics. Before that, everything was ultimately built up from pure hydrogen in the immediate aftermath of the big bang, which initiated the universe.

There is a temptation to argue that, although God may not be needed to explain the evolution of complex order once the universe, with its fundamental laws of physics, had begun, we do need a God to explain the origin of all things. This idea doesn't leave God with very much to do: just set off the big bang, then sit back and wait for everything to happen. The physical chemist Peter Atkins, in his beautifully written book The Creation, postulates a lazy God who strove to do as little as possible in order to initiate everything. Atkins explains how each step in the history of the universe followed, by simple physical law, from its predecessor. He thus pares down the amount of work that the lazy creator would need to do and eventually concludes that he would in fact have needed to do nothing at all!

The details of the early phase of the universe belong to the realm of physics, whereas I am a biologist, more concerned with the later phases of the evolution of complexity. For me, the important point is that, even if the physicist needs to postulate an irreducible minimum that had to be present in the beginning, in order for the universe to get started, that irreducible minimum is certainly extremely simple. By definition, explanations that build on simple premises are more plausible and more satisfying than explanations that have to postulate complex and statistically improbable beginnings. And you can't get much more complex than an Almighty God!

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The Information Challenge
By Richard Dawkins
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In September 1997, I allowed an Australian film crew into my house in Oxford without realising that their purpose was creationist propaganda. In the course of a suspiciously amateurish interview, they issued a truculent challenge to me to "give an example of a genetic mutation or an evolutionary process which can be seen to increase the information in the genome." It is the kind of question only a creationist would ask in that way, and it was at this point I tumbled to the fact that I had been duped into granting an interview to creationists - a thing I normally don't do, for good reasons. In my anger I refused to discuss the question further, and told them to stop the camera. However, I eventually withdrew my peremptory termination of the interview as a whole. This was solely because they pleaded with me that they had come all the way from Australia specifically in order to interview me. Even if this was a considerable exaggeration, it seemed, on reflection, ungenerous to tear up the legal release form and throw them out. I therefore relented.

My generosity was rewarded in a fashion that anyone familiar with fundamentalist tactics might have predicted. When I eventually saw the film a year later 1, I found that it had been edited to give the false impression that I was incapable of answering the question about information content 2. In fairness, this may not have been quite as intentionally deceitful as it sounds. You have to understand that these people really believe that their question cannot be answered! Pathetic as it sounds, their entire journey from Australia seems to have been a quest to film an evolutionist failing to answer it.

With hindsight - given that I had been suckered into admitting them into my house in the first place - it might have been wiser simply to answer the question. But I like to be understood whenever I open my mouth - I have a horror of blinding people with science - and this was not a question that could be answered in a soundbite. First you first have to explain the technical meaning of "information". Then the relevance to evolution, too, is complicated - not really difficult but it takes time. Rather than engage now in further recriminations and disputes about exactly what happened at the time of the interview (for, to be fair, I should say that the Australian producer's memory of events seems to differ from mine), I shall try to redress the matter now in constructive fashion by answering the original question, the "Information Challenge", at adequate length - the sort of length you can achieve in a proper article.
Information

The technical definition of "information" was introduced by the American engineer Claude Shannon in 1948. An employee of the Bell Telephone Company, Shannon was concerned to measure information as an economic commodity. It is costly to send messages along a telephone line. Much of what passes in a message is not information: it is redundant. You could save money by recoding the message to remove the redundancy. Redundancy was a second technical term introduced by Shannon, as the inverse of information. Both definitions were mathematical, but we can convey Shannon's intuitive meaning in words.

Redundancy is any part of a message that is not informative, either because the recipient already knows it (is not surprised by it) or because it duplicates other parts of the message. In the sentence "Rover is a poodle dog", the word "dog" is redundant because "poodle" already tells us that Rover is a dog. An economical telegram would omit it, thereby increasing the informative proportion of the message. "Arr JFK Fri pm pls mt BA Cncrd flt" carries the same information as the much longer, but more redundant, "I'll be arriving at John F Kennedy airport on Friday evening; please meet the British Airways Concorde flight". Obviously the brief, telegraphic message is cheaper to send (although the recipient may have to work harder to decipher it - redundancy has its virtues if we forget economics). Shannon wanted to find a mathematical way to capture the idea that any message could be broken into the information (which is worth paying for), the redundancy (which can, with economic advantage, be deleted from the message because, in effect, it can be reconstructed by the recipient) and the noise (which is just random rubbish).

"It rained in Oxford every day this week" carries relatively little information, because the receiver is not surprised by it. On the other hand, "It rained in the Sahara desert every day this week" would be a message with high information content, well worth paying extra to send. Shannon wanted to capture this sense of information content as "surprise value". It is related to the other sense - "that which is not duplicated in other parts of the message" - because repetitions lose their power to surprise. Note that Shannon's definition of the quantity of information is independent of whether it is true. The measure he came up with was ingenious and intuitively satisfying. Let's estimate, he suggested, the receiver's ignorance or uncertainty before receiving the message, and then compare it with the receiver's remaining ignorance after receiving the message. The quantity of ignorance-reduction is the information content. Shannon's unit of information is the bit, short for "binary digit". One bit is defined as the amount of information needed to halve the receiver's prior uncertainty, however great that prior uncertainty was (mathematical readers will notice that the bit is, therefore, a logarithmic measure).

In practice, you first have to find a way of measuring the prior uncertainty - that which is reduced by the information when it comes. For particular kinds of simple message, this is easily done in terms of probabilities. An expectant father watches the Caesarian birth of his child through a window into the operating theatre. He can't see any details, so a nurse has agreed to hold up a pink card if it is a girl, blue for a boy. How much information is conveyed when, say, the nurse flourishes the pink card to the delighted father? The answer is one bit - the prior uncertainty is halved. The father knows that a baby of some kind has been born, so his uncertainty amounts to just two possibilities - boy and girl - and they are (for purposes of this discussion) equal. The pink card halves the father's prior uncertainty from two possibilities to one (girl). If there'd been no pink card but a doctor had walked out of the operating theatre, shook the father's hand and said "Congratulations old chap, I'm delighted to be the first to tell you that you have a daughter", the information conveyed by the 17 word message would still be only one bit.

Computer information

Computer information is held in a sequence of noughts and ones. There are only two possibilities, so each 0 or 1 can hold one bit. The memory capacity of a computer, or the storage capacity of a disc or tape, is often measured in bits, and this is the total number of 0s or 1s that it can hold. For some purposes, more convenient units of measurement are the byte (8 bits), the kilobyte (1000 bytes or 8000 bits), the megabyte (a million bytes or 8 million bits) or the gigabyte (1000 million bytes or 8000 million bits). Notice that these figures refer to the total available capacity. This is the maximum quantity of information that the device is capable of storing. The actual amount of information stored is something else. The capacity of my hard disc happens to be 4.2 gigabytes. Of this, about 1.4 gigabytes are actually being used to store data at present. But even this is not the true information content of the disc in Shannon's sense. The true information content is smaller, because the information could be more economically stored. You can get some idea of the true information content by using one of those ingenious compression programs like "Stuffit". Stuffit looks for redundancy in the sequence of 0s and 1s, and removes a hefty proportion of it by recoding - stripping out internal predictability. Maximum information content would be achieved (probably never in practice) only if every 1 or 0 surprised us equally. Before data is transmitted in bulk around the Internet, it is routinely compressed to reduce redundancy.

That's good economics. But on the other hand it is also a good idea to keep some redundancy in messages, to help correct errors. In a message that is totally free of redundancy, after there's been an error there is no means of reconstructing what was intended. Computer codes often incorporate deliberately redundant "parity bits" to aid in error detection. DNA, too, has various error-correcting procedures which depend upon redundancy. When I come on to talk of genomes, I'll return to the three-way distinction between total information capacity, information capacity actually used, and true information content.

It was Shannon's insight that information of any kind, no matter what it means, no matter whether it is true or false, and no matter by what physical medium it is carried, can be measured in bits, and is translatable into any other medium of information. The great biologist J B S Haldane used Shannon's theory to compute the number of bits of information conveyed by a worker bee to her hivemates when she "dances" the location of a food source (about 3 bits to tell about the direction of the food and another 3 bits for the distance of the food). In the same units, I recently calculated that I'd need to set aside 120 megabits of laptop computer memory to store the triumphal opening chords of Richard Strauss's "Also Sprach Zarathustra" (the "2001" theme) which I wanted to play in the middle of a lecture about evolution. Shannon's economics enable you to calculate how much modem time it'll cost you to e-mail the complete text of a book to a publisher in another land. Fifty years after Shannon, the idea of information as a commodity, as measurable and interconvertible as money or energy, has come into its own.

DNA information

DNA carries information in a very computer-like way, and we can measure the genome's capacity in bits too, if we wish. DNA doesn't use a binary code, but a quaternary one. Whereas the unit of information in the computer is a 1 or a 0, the unit in DNA can be T, A, C or G. If I tell you that a particular location in a DNA sequence is a T, how much information is conveyed from me to you? Begin by measuring the prior uncertainty. How many possibilities are open before the message "T" arrives? Four. How many possibilities remain after it has arrived? One. So you might think the information transferred is four bits, but actually it is two. Here's why (assuming that the four letters are equally probable, like the four suits in a pack of cards). Remember that Shannon's metric is concerned with the most economical way of conveying the message. Think of it as the number of yes/no questions that you'd have to ask in order to narrow down to certainty, from an initial uncertainty of four possibilities, assuming that you planned your questions in the most economical way. "Is the mystery letter before D in the alphabet?" No. That narrows it down to T or G, and now we need only one more question to clinch it. So, by this method of measuring, each "letter" of the DNA has an information capacity of 2 bits.

Whenever prior uncertainty of recipient can be expressed as a number of equiprobable alternatives N, the information content of a message which narrows those alternatives down to one is log2N (the power to which 2 must be raised in order to yield the number of alternatives N). If you pick a card, any card, from a normal pack, a statement of the identity of the card carries log252, or 5.7 bits of information. In other words, given a large number of guessing games, it would take 5.7 yes/no questions on average to guess the card, provided the questions are asked in the most economical way. The first two questions might establish the suit. (Is it red? Is it a diamond?) the remaining three or four questions would successively divide and conquer the suit (is it a 7 or higher? etc.), finally homing in on the chosen card. When the prior uncertainty is some mixture of alternatives that are not equiprobable, Shannon's formula becomes a slightly more elaborate weighted average, but it is essentially similar. By the way, Shannon's weighted average is the same formula as physicists have used, since the nineteenth century, for entropy. The point has interesting implications but I shall not pursue them here.

Information and evolution

That's enough background on information theory. It is a theory which has long held a fascination for me, and I have used it in several of my research papers over the years. Let's now think how we might use it to ask whether the information content of genomes increases in evolution. First, recall the three way distinction between total information capacity, the capacity that is actually used, and the true information content when stored in the most economical way possible. The total information capacity of the human genome is measured in gigabits. That of the common gut bacterium Escherichia coli is measured in megabits. We, like all other animals, are descended from an ancestor which, were it available for our study today, we'd classify as a bacterium. So perhaps, during the billions of years of evolution since that ancestor lived, the information capacity of our genome has gone up about three orders of magnitude (powers of ten) - about a thousandfold. This is satisfyingly plausible and comforting to human dignity. Should human dignity feel wounded, then, by the fact that the crested newt, Triturus cristatus, has a genome capacity estimated at 40 gigabits, an order of magnitude larger than the human genome? No, because, in any case, most of the capacity of the genome of any animal is not used to store useful information. There are many nonfunctional pseudogenes (see below) and lots of repetitive nonsense, useful for forensic detectives but not translated into protein in the living cells. The crested newt has a bigger "hard disc" than we have, but since the great bulk of both our hard discs is unused, we needn't feel insulted. Related species of newt have much smaller genomes. Why the Creator should have played fast and loose with the genome sizes of newts in such a capricious way is a problem that creationists might like to ponder. From an evolutionary point of view the explanation is simple (see The Selfish Gene pp 44-45 and p 275 in the Second Edition).

Gene duplication

Evidently the total information capacity of genomes is very variable across the living kingdoms, and it must have changed greatly in evolution, presumably in both directions. Losses of genetic material are called deletions. New genes arise through various kinds of duplication. This is well illustrated by haemoglobin, the complex protein molecule that transports oxygen in the blood.

Human adult haemoglobin is actually a composite of four protein chains called globins, knotted around each other. Their detailed sequences show that the four globin chains are closely related to each other, but they are not identical. Two of them are called alpha globins (each a chain of 141 amino acids), and two are beta globins (each a chain of 146 amino acids). The genes coding for the alpha globins are on chromosome 11; those coding for the beta globins are on chromosome 16. On each of these chromosomes, there is a cluster of globin genes in a row, interspersed with some junk DNA. The alpha cluster, on Chromosome 11, contains seven globin genes. Four of these are pseudogenes, versions of alpha disabled by faults in their sequence and not translated into proteins. Two are true alpha globins, used in the adult. The final one is called zeta and is used only in embryos. Similarly the beta cluster, on chromosome 16, has six genes, some of which are disabled, and one of which is used only in the embryo. Adult haemoglobin, as we've seen contains two alpha and two beta chains.

Never mind all this complexity. Here's the fascinating point. Careful letter-by-letter analysis shows that these different kinds of globin genes are literally cousins of each other, literally members of a family. But these distant cousins still coexist inside our own genome, and that of all vertebrates. On a the scale of whole organism, the vertebrates are our cousins too. The tree of vertebrate evolution is the family tree we are all familiar with, its branch-points representing speciation events - the splitting of species into pairs of daughter species. But there is another family tree occupying the same timescale, whose branches represent not speciation events but gene duplication events within genomes.

The dozen or so different globins inside you are descended from an ancient globin gene which, in a remote ancestor who lived about half a billion years ago, duplicated, after which both copies stayed in the genome. There were then two copies of it, in different parts of the genome of all descendant animals. One copy was destined to give rise to the alpha cluster (on what would eventually become Chromosome 11 in our genome), the other to the beta cluster (on Chromosome 16). As the aeons passed, there were further duplications (and doubtless some deletions as well). Around 400 million years ago the ancestral alpha gene duplicated again, but this time the two copies remained near neighbours of each other, in a cluster on the same chromosome. One of them was destined to become the zeta of our embryos, the other became the alpha globin genes of adult humans (other branches gave rise to the nonfunctional pseudogenes I mentioned). It was a similar story along the beta branch of the family, but with duplications at other moments in geological history.

Now here's an equally fascinating point. Given that the split between the alpha cluster and the beta cluster took place 500 million years ago, it will of course not be just our human genomes that show the split - possess alpha genes in a different part of the genome from beta genes. We should see the same within-genome split if we look at any other mammals, at birds, reptiles, amphibians and bony fish, for our common ancestor with all of them lived less than 500 million years ago. Wherever it has been investigated, this expectation has proved correct. Our greatest hope of finding a vertebrate that does not share with us the ancient alpha/beta split would be a jawless fish like a lamprey, for they are our most remote cousins among surviving vertebrates; they are the only surviving vertebrates whose common ancestor with the rest of the vertebrates is sufficiently ancient that it could have predated the alpha/beta split. Sure enough, these jawless fishes are the only known vertebrates that lack the alpha/beta divide.

Gene duplication, within the genome, has a similar historic impact to species duplication ("speciation") in phylogeny. It is responsible for gene diversity, in the same way as speciation is responsible for phyletic diversity. Beginning with a single universal ancestor, the magnificent diversity of life has come about through a series of branchings of new species, which eventually gave rise to the major branches of the living kingdoms and the hundreds of millions of separate species that have graced the earth. A similar series of branchings, but this time within genomes - gene duplications - has spawned the large and diverse population of clusters of genes that constitutes the modern genome.

The story of the globins is just one among many. Gene duplications and deletions have occurred from time to time throughout genomes. It is by these, and similar means, that genome sizes can increase in evolution. But remember the distinction between the total capacity of the whole genome, and the capacity of the portion that is actually used. Recall that not all the globin genes are actually used. Some of them, like theta in the alpha cluster of globin genes, are pseudogenes, recognizably kin to functional genes in the same genomes, but never actually translated into the action language of protein. What is true of globins is true of most other genes. Genomes are littered with nonfunctional pseudogenes, faulty duplicates of functional genes that do nothing, while their functional cousins (the word doesn't even need scare quotes) get on with their business in a different part of the same genome. And there's lots more DNA that doesn't even deserve the name pseudogene. It, too, is derived by duplication, but not duplication of functional genes. It consists of multiple copies of junk, "tandem repeats", and other nonsense which may be useful for forensic detectives but which doesn't seem to be used in the body itself.

Once again, creationists might spend some earnest time speculating on why the Creator should bother to litter genomes with untranslated pseudogenes and junk tandem repeat DNA.

Information in the genome

Can we measure the information capacity of that portion of the genome which is actually used? We can at least estimate it. In the case of the human genome it is about 2% - considerably less than the proportion of my hard disc that I have ever used since I bought it. Presumably the equivalent figure for the crested newt is even smaller, but I don't know if it has been measured. In any case, we mustn't run away with a chaunvinistic idea that the human genome somehow ought to have the largest DNA database because we are so wonderful. The great evolutionary biologist George C Williams has pointed out that animals with complicated life cycles need to code for the development of all stages in the life cycle, but they only have one genome with which to do so. A butterfly's genome has to hold the complete information needed for building a caterpillar as well as a butterfly. A sheep liver fluke has six distinct stages in its life cycle, each specialised for a different way of life. We shouldn't feel too insulted if liver flukes turned out to have bigger genomes than we have (actually they don't).

Remember, too, that even the total capacity of genome that is actually used is still not the same thing as the true information content in Shannon's sense. The true information content is what's left when the redundancy has been compressed out of the message, by the theoretical equivalent of Stuffit. There are even some viruses which seem to use a kind of Stuffit-like compression. They make use of the fact that the RNA (not DNA in these viruses, as it happens, but the principle is the same) code is read in triplets. There is a "frame" which moves along the RNA sequence, reading off three letters at a time. Obviously, under normal conditions, if the frame starts reading in the wrong place (as in a so-called frame-shift mutation), it makes total nonsense: the "triplets" that it reads are out of step with the meaningful ones. But these splendid viruses actually exploit frame-shifted reading. They get two messages for the price of one, by having a completely different message embedded in the very same series of letters when read frame-shifted. In principle you could even get three messages for the price of one, but I don't know whether there are any examples.
Information in the body

It is one thing to estimate the total information capacity of a genome, and the amount of the genome that is actually used, but it's harder to estimate its true information content in the Shannon sense. The best we can do is probably to forget about the genome itself and look at its product, the "phenotype", the working body of the animal or plant itself. In 1951, J W S Pringle, who later became my Professor at Oxford, suggested using a Shannon-type information measure to estimate "complexity". Pringle wanted to express complexity mathematically in bits, but I have long found the following verbal form helpful in explaining his idea to students.

We have an intuitive sense that a lobster, say, is more complex (more "advanced", some might even say more "highly evolved") than another animal, perhaps a millipede. Can we measure something in order to confirm or deny our intuition? Without literally turning it into bits, we can make an approximate estimation of the information contents of the two bodies as follows. Imagine writing a book describing the lobster. Now write another book describing the millipede down to the same level of detail. Divide the word-count in one book by the word-count in the other, and you have an approximate estimate of the relative information content of lobster and millipede. It is important to specify that both books describe their respective animals "down to the same level of detail". Obviously if we describe the millipede down to cellular detail, but stick to gross anatomical features in the case of the lobster, the millipede would come out ahead.

But if we do the test fairly, I'll bet the lobster book would come out longer than the millipede book. It's a simple plausibility argument, as follows. Both animals are made up of segments - modules of bodily architecture that are fundamentally similar to each other, arranged fore-and-aft like the trucks of a train. The millipede's segments are mostly identical to each other. The lobster's segments, though following the same basic plan (each with a nervous ganglion, a pair of appendages, and so on) are mostly different from each other. The millipede book would consist of one chapter describing a typical segment, followed by the phrase "Repeat N times" where N is the number of segments. The lobster book would need a different chapter for each segment. This isn't quite fair on the millipede, whose front and rear end segments are a bit different from the rest. But I'd still bet that, if anyone bothered to do the experiment, the estimate of lobster information content would come out substantially greater than the estimate of millipede information content.

It's not of direct evolutionary interest to compare a lobster with a millipede in this way, because nobody thinks lobsters evolved from millipedes. Obviously no modern animal evolved from any other modern animal. Instead, any pair of modern animals had a last common ancestor which lived at some (in principle) discoverable moment in geological history. Almost all of evolution happened way back in the past, which makes it hard to study details. But we can use the "length of book" thought-experiment to agree upon what it would mean to ask the question whether information content increases over evolution, if only we had ancestral animals to look at.

The answer in practice is complicated and controversial, all bound up with a vigorous debate over whether evolution is, in general, progressive. I am one of those associated with a limited form of yes answer. My colleague Stephen Jay Gould tends towards a no answer. I don't think anybody would deny that, by any method of measuring - whether bodily information content, total information capacity of genome, capacity of genome actually used, or true ("Stuffit compressed") information content of genome - there has been a broad overall trend towards increased information content during the course of human evolution from our remote bacterial ancestors. People might disagree, however, over two important questions: first, whether such a trend is to be found in all, or a majority of evolutionary lineages (for example parasite evolution often shows a trend towards decreasing bodily complexity, because parasites are better off being simple); second, whether, even in lineages where there is a clear overall trend over the very long term, it is bucked by so many reversals and re-reversals in the shorter term as to undermine the very idea of progress. This is not the place to resolve this interesting controversy. There are distinguished biologists with good arguments on both sides.

Supporters of "intelligent design" guiding evolution, by the way, should be deeply committed to the view that information content increases during evolution. Even if the information comes from God, perhaps especially if it does, it should surely increase, and the increase should presumably show itself in the genome. Unless, of course - for anything goes in such addle-brained theorising - God works his evolutionary miracles by nongenetic means.

Perhaps the main lesson we should learn from Pringle is that the information content of a biological system is another name for its complexity. Therefore the creationist challenge with which we began is tantamount to the standard challenge to explain how biological complexity can evolve from simpler antecedents, one that I have devoted three books to answering (The Blind Watchmaker, River Out of Eden, Climbing Mount Improbable) and I do not propose to repeat their contents here. The "information challenge" turns out to be none other than our old friend: "How could something as complex as an eye evolve?" It is just dressed up in fancy mathematical language - perhaps in an attempt to bamboozle. Or perhaps those who ask it have already bamboozled themselves, and don't realise that it is the same old - and thoroughly answered - question.
The Genetic Book of the Dead

Let me turn, finally, to another way of looking at whether the information content of genomes increases in evolution. We now switch from the broad sweep of evolutionary history to the minutiae of natural selection. Natural selection itself, when you think about it, is a narrowing down from a wide initial field of possible alternatives, to the narrower field of the alternatives actually chosen. Random genetic error (mutation), sexual recombination and migratory mixing, all provide a wide field of genetic variation: the available alternatives. Mutation is not an increase in true information content, rather the reverse, for mutation, in the Shannon analogy, contributes to increasing the prior uncertainty. But now we come to natural selection, which reduces the "prior uncertainty" and therefore, in Shannon's sense, contributes information to the gene pool. In every generation, natural selection removes the less successful genes from the gene pool, so the remaining gene pool is a narrower subset. The narrowing is nonrandom, in the direction of improvement, where improvement is defined, in the Darwinian way, as improvement in fitness to survive and reproduce. Of course the total range of variation is topped up again in every generation by new mutation and other kinds of variation. But it still remains true that natural selection is a narrowing down from an initially wider field of possibilities, including mostly unsuccessful ones, to a narrower field of successful ones. This is analogous to the definition of information with which we began: information is what enables the narrowing down from prior uncertainty (the initial range of possibilities) to later certainty (the "successful" choice among the prior probabilities). According to this analogy, natural selection is by definition a process whereby information is fed into the gene pool of the next generation.

If natural selection feeds information into gene pools, what is the information about? It is about how to survive. Strictly it is about how to survive and reproduce, in the conditions that prevailed when previous generations were alive. To the extent that present day conditions are different from ancestral conditions, the ancestral genetic advice will be wrong. In extreme cases, the species may then go extinct. To the extent that conditions for the present generation are not too different from conditions for past generations, the information fed into present-day genomes from past generations is helpful information. Information from the ancestral past can be seen as a manual for surviving in the present: a family bible of ancestral "advice" on how to survive today. We need only a little poetic licence to say that the information fed into modern genomes by natural selection is actually information about ancient environments in which ancestors survived.

This idea of information fed from ancestral generations into descendant gene pools is one of the themes of my new book, Unweaving the Rainbow. It takes a whole chapter, "The Genetic Book of the Dead", to develop the notion, so I won't repeat it here except to say two things. First, it is the whole gene pool of the species as a whole, not the genome of any particular individual, which is best seen as the recipient of the ancestral information about how to survive. The genomes of particular individuals are random samples of the current gene pool, randomised by sexual recombination. Second, we are privileged to "intercept" the information if we wish, and "read" an animal's body, or even its genes, as a coded description of ancestral worlds. To quote from Unweaving the Rainbow: "And isn't it an arresting thought? We are digital archives of the African Pliocene, even of Devonian seas; walking repositories of wisdom out of the old days. You could spend a lifetime reading in this ancient library and die unsated by the wonder of it."

1 The producers never deigned to send me a copy: I completely forgot about it until an American colleague called it to my attention.

2 See Barry Williams (1998): "Creationist Deception Exposed", The Skeptic 18, 3, pp 7-10, for an account of how my long pause (trying to decide whether to throw them out) was made to look like hesitant inability to answer the question, followed by an apparently evasive answer to a completely different question.

The Joy of Living Dangerously
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Sanderson of Oundle
Richard Dawkins

It has been an educational week for me. Home life overshadowed by A-level examination horrors, I escaped to London to address a conference of science teachers. On the train, in anticipation of the inaugural 'Oundle Lecture' which I am nervously to give next week, I read H G Wells's biography of that school's famous old Head: The Story of a Great Schoolmaster: being a plain account of the life and ideas of Sanderson of Oundle. The book begins in terms which initially struck me as a little over the top: "I think him beyond question the greatest man I have ever known with any degree of intimacy." But it led me on to read the official biography, Sanderson of Oundle, written by a large, anonymous syndicate of his former pupils (Sanderson believed in cooperation instead of striving for individual recognition).
Walking party with Sanderson
I now see what Wells meant. And I am sure that F W Sanderson (1857-1922) would have been horrified to learn what I learned from the teachers I met at the London conference, about the stifling effects of exams, and the government obsession with measuring a school's performance by them. He would have been aghast at the anti-educational hoops that young people now have to jump through in order to get into university. He would have been openly contemptuous of the pussyfooting, lawyer-driven fastidiousness of 'Health and Safety', and of the accountant-driven league-tables that dominate modern education. Quoting Bertrand Russell, he disliked competition and 'possessiveness' as a motive for anything in education.

Sanderson of Oundle ended up second only to Arnold of Rugby in fame, but Sanderson was not born to the world of public schools. Today, he would surely have been drawn to a large, mixed Comprehensive. His relatively humble origins, his northern accent and his lack of Holy Orders gave him a rough ride with the Classical 'dominies' whom he found on arrival at the small and run-down Oundle of 1892. So rebarbative were his first five years, Sanderson actually wrote out his letter of resignation. Fortunately he never sent it. By the time of his death thirty years later, Oundle's numbers had increased from 100 to 500, it had become the foremost school for science and especially engineering in the country, and he was loved and respected by generations of grateful pupils and colleagues. More important, Sanderson had developed a philosophy of education which we should heed to this day.

He was said to lack fluency as a public speaker, but his sermons in the School Chapel could achieve Churchillian heights.

Mighty men of science and mighty deeds. A Newton who binds the universe together in uniform law; Lagrange, Laplace, Leibnitz with their wondrous mathematical harmonies; Coulomb measuring out electricity . . . Faraday, Ohm, Ampère, Joule, Maxwell, Hertz, Röntgen; and in another branch of science, Cavendish, Davy, Dalton, Dewar; and in another, Darwin, Mendel, Pasteur, Lister, Sir Ronald Ross. All these and many others, and some whose names have no memorial, form a great host of heroes, an army of soldiers – fit companions of those of whom the poets have sung . . . There is the great Newton at the head of this list comparing himself to a child playing on the seashore gathering pebbles, whilst he could see with prophetic vision the immense ocean of truth yet unexplored before him . . .

How often did you hear that sort of thing in a religious service? Or this, his genial indictment of mindless patriotism, delivered on Empire Day at the close of the First World War. He went right through the Sermon on the Mount, concluding each Beatitude with a mocking "Rule Britannia.

Blessed are they that mourn, for they shall be comforted. Rule Britannia!
Blessed are the meek, for they shall inherit the Earth. Rule Britannia!
Blessed are the peacemakers, for they shall be called the children of God. Rule Britannia!
Blessed are they that have been persecuted for righteousness sake. Rule Britannia!

Dear souls! My dear souls! I wouldn't lead you astray for anything.

Sanderson's passionate desire to give the boys freedom to fulfil themselves would have thrown Health and Safety into a hissy fit, and set today's lawyers licking their acquisitive chops with anticipation. He directed that the laboratories should be left unlocked at all times, so that boys could go in and work on their own research projects, even if unsupervised. The more dangerous chemicals were locked up, “but enough was left about to disturb the equanimity of other masters who had less faith than the Head in that providence which looks after the young.” The same open door policy applied to the school workshops, the finest in the country, filled with state-of-the-art machine tools which were Sanderson’s pride and joy. Under these conditions, one boy did damage a ‘surface plate’ by using it as an anvil against which to hammer a rivet.

That did disconcert the Head for a little when it was discovered. But my punishment was quite Oundelian. I had to make a study of the manufacture and use of surface plates and bring a report and explain it all to him. And after that I found I had learnt to look twice at a fine piece of work before I used it ill.

Incidents like this led eventually, and not surprisingly, to the workshops and laboratories again being locked when there was no adult supervision. But some boys felt the deprivation acutely and, in true Sandersonian fashion, they set out, in the workshops and the library (another of Sanderson’s personal prides) to make a thorough study of locks and how to pick them.

In our enthusiasm we made skeleton keys for all Oundle, not only for the laboratories but for private rooms as well. For weeks we used the laboratories and workshops as we had grown accustomed to use them, but now with a keen care of the expensive apparatus and with precautions to leave nothing disorderly to betray our visits. It seemed that the Head saw nothing; he had a great gift for assuming blindness – until Speech Day came round, and then we were amazed to hear him, as he beamed upon the assembled parents, telling them the whole business, “And what do you think my boys have been doing now?”

Sanderson’s hatred of any locked door which might stand between a boy and some worthwhile enthusiasm symbolised his whole attitude to education. Another anecdote. A certain boy was so keen on a project he was working on that he used to steal out of the dormitory at 2 am to read in the (unlocked, of course) library. The Headmaster caught him there, and roared his terrible wrath for this breach of discipline (he had a famous temper and one of his maxims was “Never punish except in anger”).

The thunderstorm passed. “And what are you reading, my boy, at this hour?” I told him of the work that had taken possession of me, work for which the day time was all too full. Yes, yes, he understood that. He looked over the notes I had been taking and they set his mind going. He sat down beside me to read them. They dealt with the development of metallurgical processes, and he began to talk to me of discovery and the values of discovery, the incessant reaching out of men towards knowledge and power, the significance of this desire to know and make and what we in the school were doing in that process. We talked, he talked for nearly an hour in that still nocturnal room. It was one of the greatest, most formative hours in my life . . . “Go back to bed, my boy. We must find some time for you in the day for this.”

Far from seeking garlands in examination league tables by fostering only high flyers,

Sanderson’s most strenuous labours were on behalf of the average, and specially the ‘dull’ boys. He would never admit the word: if a boy was dull it was because he was being forced in the wrong direction, and he would make endless experiments to find how to get his interest. At the same time he did not neglect obvious talent, but here he felt the problem was easy. He loved to give a clever boy abundant time and material to revel in his special subject. To do this he would spend immense labour over complicated details of organisation; his extraordinary intuition and memory – he knew every boy by name and had a complete mental picture of his ability and character – alone made it possible to deal with each individual according to his needs. But if some boy was standing still and showing no sign of life, he would adopt any expedient to get his attention . . . It was not enough that the majority should do well. “I never like to fail with a boy.”

In spite of – or perhaps because of – Sanderson’s contempt for league tables, Oundle did well in them. A faded newspaper cutting, yellowing and regrettably undated, dropped out of my secondhand copy of Wells’s book:

“In the higher certificates of the Oxford and Cambridge School examinations Oundle once again leads, having 76 successes. Shrewsbury and Marlborough tie for second place at 49 each.”

Sanderson died in 1922, after struggling to the end of a major lecture to a gathering of scientists, at University College, London. The chairman, H G Wells himself, had just proposed a vote of thanks and called for the first question from the floor, when Sanderson dropped dead on the platform. The lecture had not been intended as a valediction, but the eye of sentiment can read the published text as Sanderson's educational testament, a summation of all that he had learned in 30 years as a supremely successful and deeply loved headmaster.

My head ringing with the last words of this remarkable man, I closed the book and travelled on to University College, London, site of his swansong and of my own modest address to the conference of science schoolteachers. My subject was evolution, and the recent outbreak of American-style Young Earth Creationism in Emmanuel College, Gateshead. I offered an analogy which teachers might use to bring home to their pupils the true antiquity of the universe. If a history were written at a rate of one century per page, how thick would the book of the universe be? In the view of a Young Earth Creationist, the whole history of the universe, on this scale, would fit comfortably into a slender paperback. That would be the book of the Head of Science at Emmanuel, recently given a resounding vote of confidence by Ofsted, with the approval of the Prime Minister and the Minister of Education. And the scientific answer to the question? To accommodate all the volumes of the history of the universe on the same scale, you'd need a bookshelf ten miles long. That gives the order of magnitude of the yawning gap between science on the one hand, and the science teaching at the infamous Gateshead school on the other. This is not some dispute of scientific detail. It is the difference between a single paperback and a library of a million books. What would have offended Sanderson about the diet of falsehood now being fed to the children of Gateshead is not just that it is false but that it is petty, small-minded, parochial, unimaginative, unpoetic and downright boring compared to the staggering, mind-expanding truth.

After my talk, I stayed for lunch, and then was invited to join one of the separate break-out groups in the afternoon. Almost to a man and woman, the teachers were deeply worried about the A-level syllabus and the destructive effects of exam pressure on true education. One after another, the teachers came up to me to say that, much as they would like to, they didn't dare to do justice to evolution in their classes. This was not because of intimidation by fundamentalist parents (which would have been the reason in parts of America). It was simply because of the A level syllabus. Evolution gets only a tiny mention, and then only at the end of the A level course. This is preposterous for, as one of the teachers said to me, quoting the great Russian American biologist Theodosius Dobzhansky (incidentally a devout Christian, like Sanderson), “Nothing in biology makes sense except in the light of evolution.”

Without evolution, biology is a collection of miscellaneous facts. Before they learn to think in an evolutionary way, the facts that the children learn will just be facts, with no binding thread to hold them together, nothing to make them memorable or coherent. With evolution, a great light breaks through into the deepest recesses, into every corner, of the science of life. You understand not only what is, but why. How can you possibly teach biology unless you begin with evolution? Yet, time and again, I heard the same story. Teachers had wanted to introduce their pupils to life's central theorem, evolution, only to be glottal-stopped dead in their tracks: “Is that on the syllabus? Will it come up in the exam?” Sadly, the teacher had to admit that the answer was no, and returned to the rote learning of enzymes, and ‘relevant’ Human Biology.

Sanderson would have hit the roof.

His spirit lived on at Oundle. His immediate successor, Kenneth Fisher was chairing a staff meeting when there was a timid knock on the door and a small boy came in: “Please, sir, there are Black Terns down by the river.” “This can wait,” said Fisher decisively to the assembled committee. He rose from the Chair, seized his binoculars from the door and cycled off in the company of the small ornithologist, and – one can't help imagining – with the benign, ruddy-faced ghost of Sanderson beaming in their wake. Now that's education – and to hell with your league table statistics, your fact-stuffed syllabuses and your childhood-destroying, endless roster of exams.

Sanderson's tradition that the whole school, not just the choir, even the tone deaf, should rehearse and bellow a part in the annual oratorio, also survived him, and has been widely imitated by other schools. Alas, his most famous innovation, the Week in Workshops (a full week for every boy in every term with all other work suspended) has not survived, but it was still going during my time in the fifties. It was later killed by exam pressure, of course, but a wonderfully Sandersonian phoenix has risen from its ashes. The boys, and now girls, cooperate out of school hours to build cars, to a special Oundle design. They don't just assemble a kit, with parts supplied from elsewhere. So far as possible all the parts are cast, by the young people, in the school's own foundry. They have cooperated to build more than thirty sports cars during the past five years, and they are now working on an aircraft. So, Mr Sanderson, dear soul, eighty years on you have your immortality, in the only way to which a man can reasonably aspire. The last word should be yours:

“I agree with Nietzsche that “The secret of a joyful life is to live dangerously.” A joyful life is an active life -- it is not a dull static state of so-called happiness. Full of the burning fire of enthusiasm, anarchic, revolutionary, energetic, daemonic, Dionysian, filled to overflowing with the terrific urge to create -- such is the life of the man who risks safety and happiness for the sake of growth and happiness.

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The "know-nothings", the "know-alls", and the "no-contests"
(has no official title)

A lecture by Richard Dawkins extracted from The Nullifidian (Dec 94)

Richard Dawkins, well-known for his books on evolution, took part in a debate with the Archbishop of York, Dr John Habgood, on the existence of God at the Edinburgh science festival last Easter. [Easter '92 ed.] The science correspondent of The Observer reported that the "withering" Richard Dawkins clearly believed the "God should be spoken of in the same way as Father Christmas or the Tooth Fairy". He [the correspondent] overheard a gloomy cleric comment on the debate: "That was easy to sum up. Lions 10, Christians nil".

Religious people split into three main groups when faced with science. I shall label them the "know-nothings", the "know-alls", and the "no-contests". I suspect that Dr John Habgood, the Archbishop of York, probably belongs to the third of these groups, so I shall begin with them.

The "no-contests" are rightly reconciled to the fact that religion cannot compete with science on its own ground. They think there is no contest between science and religion, because they are simply about different things. the biblical account of the origin of the universe (the origin of life, the diversity of species, the origin of man) -- all those things are now known to be untrue.

The "no-contests" have no trouble with this: they regard it as naive in the extreme, almost bad taste to ask of a biblical story, is it true? True, they say, true? Of course it isn't true in any crude literal sense. Science and religion are not competing for the same territory. They are about different things. They are equally true, but in their different ways.

A favourite and thoroughly meaningless phrase is "religious dimension". You meet this in statements such as "science is all very well as far as it goes, but it leaves out the religious dimension".

The "know-nothings", or fundamentalists, are in one way more honest. They are true to history. They recognize that until recently one of religion's main functions was scientific: the explanation of existence, of the universe, of life. Historically, most religions have had or even been a cosmology and a biology. I suspect that today if you asked people to justify their belief in God, the dominant reason would be scientific. Most people, I believe, think that you need a God to explain the existence of the world, and especially the existence of life. They are wrong, but our education system is such that many people don't know it.

They are also true to history because you can't escape the scientific implications of religion. A universe with a God would like quite different from a universe without one. A physics, a biology where there is a God is bound to look different. So the most basic claims of religion are scientific. Religion is a scientific theory.

I am sometimes accused of arrogant intolerance in my treatment of creationists. Of course arrogance is an unpleasant characteristic, and I should hate to be thought arrogant in a general way. But there are limits! To get some idea of what it is like being a professional student of evolution, asked to have a serious debate with creationists, the following comparison is a fair one. Imagine yourself a classical scholar who has spent a lifetime studying Roman history in all its rich detail. Now somebody comes along, with a degree in marine engineering or mediaeval musicology, and tries to argue that the Romans never existed. Wouldn't you find it hard to suppress your impatience? And mightn't it look a bit like arrogance?

My third group, the "know-alls" (I unkindly name them that because I find their position patronising), think religion is good for people, perhaps good for society. Perhaps good because it consoles them in death or bereavement, perhaps because it provides a moral code.

Whether or not the actual beliefs of the religion are true doesn't matter. Maybe there isn't a God; we educated people know there is precious little evidence for one, let alone for ideas such as the Virgin birth or the Resurrection. but the uneducated masses need a God to keep them out of mischief or to comfort them in bereavement. The little matter of God's probably non-existence can be brushed to one side in the interest of greater social good. I need say not more about the "know-alls" because they wouldn't claim to have anything to contribute to scientific truth.

Is God a Superstring?

I shall now return to the "no-contests". The argument they mount is certainly worth serious examination, but I think that we shall find it has little more merit than those of the other groups.

God is not an old man with a white beard in the sky. Right then, what is God? And now come the weasel words. these are very variable. "God is not out there, he is in all of us." God is the ground of all being." "God is the essence of life." "God is the universe." "Don't you believe in the universe?" "Of course I believe in the universe." "Then you believe in God." "God is love, don't you believe in love?" "Right, then you believe in God?"

Modern physicists sometimes wax a bit mystical when they contemplate questions such as why the big bang happened when it did, why the laws of physics are these laws and not those laws, why the universe exists at all, and so on. Sometimes physicists may resort to saying that there is an inner core of mystery that we don't understand, and perhaps never can; and they may then say that perhaps this inner core of mystery is another name for God. Or in Stephen Hawkings's words, if we understand these things, we shall perhaps "know the mind of God."

The trouble is that God in this sophisticated, physicist's sense bears no resemblance to the God of the Bible or any other religion. If a physicist says God is another name for Planck's constant, or God is a superstring, we should take it as a picturesque metaphorical way of saying that the nature of superstrings or the value of Planck's constant is a profound mystery. It has obviously not the smallest connection with a being capable of forgiving sins, a being who might listen to prayers, who cares about whether or not the Sabbath begins at 5pm or 6pm, whether you wear a veil or have a bit of arm showing; and no connection whatever with a being capable of imposing a death penalty on His son to expiate the sins of the world before and after he was born.
The Fabulous Bible

The same is true of attempts to identify the big bang of modern cosmology with the myth of Genesis. There is only an utterly trivial resemblance between the sophisticated conceptions of modern physics, and the creation myths of the Babylonians and the Jews that we have inherited.

What do the "no-contests" say about those parts of scripture and religious teaching that once-upon-a-time would have been unquestioned religious and scientific truths; the creation of the world the creation of life, the various miracles of the Old and New Testaments,, survival after death, the Virgin Birth? These stories have become, in the hands of the "no-contests", little more than moral fables, the equivalent of Aesop of Hans Anderson. There is nothing wrong with that, but it is irritating that they almost never admit this is what they are doing.

For instance, I recently heard the previous Chief Rabbi, Sir Immanuel Jacobovits, talking about the evils of racism. Racism is evil, and it deserves a better argument against it that the one he gave. Adam and Eve, he argued, were the ancestors of all human kind. Therefore, all human kind belongs to one race, the human race.

What are we going to make of an argument like that? The Chief Rabbi is an educated man, he obviously doesn't believe in Adam and Eve, so what exactly did he think he was saying?

He must have been using Adam and Eve as a fable, just as one might use the story of Jack the Giantkiller or Cinderella to illustrate some laudable moral homily.

I have the impression that clergymen are so used to treating the biblical stories as fables that they have forgotten the difference between fact and fiction. It's like the people who, when somebody dies on The Archers, write letters of condolence to the others.
Inheriting Religion

As a Darwinian, something strikes me when I look at religion. Religion shows a pattern of heredity which I think is similar to genetic heredity. The vast majority of people have an allegiance to one particular religion. there are hundreds of different religious sects, and every religious person is loyal to just one of those.

Out of all of the sects in the world, we notice an uncanny coincidence: the overwhelming majority just happen to choose the one that their parents belong to. Not the sect that has the best evidence in its favour, the best miracles, the best moral code, the best cathedral, the best stained glass, the best music: when it comes to choosing from the smorgasbord of available religions, their potential virtues seem to count for nothing, compared to the matter of heredity.

This is an unmistakable fact; nobody could seriously deny it. Yet people with full knowledge of the arbitrary nature of this heredity, somehow manage to go on believing in their religion, often with such fanaticism that they are prepared to murder people who follow a different one.

Truths about the cosmos are true all around the universe. They don't differ in Pakistan, Afghanistan, Poland, or Norway. Yet, we are apparently prepared to accept that the religion we adopt is a matter of an accident of geography.

If you ask people why they are convinced of the truth of their religion, they don't appeal to heredity. Put like that it sounds too obviously stupid. Nor do they appeal to evidence. There isn't any, and nowadays the better educated admit it. No, they appeal to faith. Faith is the great cop-out, the great excuse to evade the need to think and evaluate evidence. Faith is belief in spite of, even perhaps because of, the lack of evidence. The worst thing is that the rest of us are supposed to respect it: to treat it with kid gloves.

If a slaughterman doesn't comply with the law in respect of cruelty to animals, he is rightly prosecuted and punished. but if he complains that his cruel practices are necessitated by religious faith, we back off apologetically and allow him to get on with it. Any other position that someone takes up can expect to be defended with reasoned argument. Faith is allowed not to justify itself by argument. Faith must be respected; and if you don't respect it, you are accused of violating human rights.

Even those with no faith have been brainwashed into respecting the faith of others. When so-called Muslim community leaders go on the radio and advocate the killing of Salman Rushdie, they are clearly committing incitement to murder--a crime for which they would ordinarily be prosecuted and possibly imprisoned. But are they arrested? They are not, because our secular society "respects" their faith, and sympathises with the deep "hurt" and "insult" to it.

Well I don't. I will respect your views if you can justify them. but if you justify your views only by saying you have faith in them, I shall not respect them.
Improbabilities

I want to end by returning to science. It is often said, mainly by the "no-contests", that although there is no positive evidence for the existence of God, nor is there evidence against his existence. So it is best to keep an open mind and be agnostic.

At first sight that seems an unassailable position, at least in the weak sense of Pascal's wager. But on second thoughts it seems a cop-out, because the same could be said of Father Christmas and tooth fairies. There may be fairies at the bottom of the garden. There is no evidence for it, but you can't prove that there aren't any, so shouldn't we be agnostic with respect to fairies?

The trouble with the agnostic argument is that it can be applied to anything. There is an infinite number of hypothetical beliefs we could hold which we can't positively disprove. On the whole, people don't believe in most of them, such as fairies, unicorns, dragons, Father Christmas, and so on. But on the whole they do believe in a creator God, together with whatever particular baggage goes with the religion of their parents.

I suspect the reason is that most people, though not belonging to the "know-nothing" party, nevertheless have a residue of feeling that Darwinian evolution isn't quite big enough to explain everything about life. All I can say as a biologist is that the feeling disappears progressively the more you read about and study what is known about life and evolution.

I want to add one thing more. The more you understand the significance of evolution, the more you are pushed away from the agnostic position and towards atheism. Complex, statistically improbable things are by their nature more difficult to explain than simple, statistically probable things.

The great beauty of Darwin's theory of evolution is that it explains how complex, difficult to understand things could have arisen step by plausible step, from simple, easy to understand beginnings. We start our explanation from almost infinitely simple beginnings: pure hydrogen and a huge amount of energy. Our scientific, Darwinian explanations carry us through a series of well-understood gradual steps to all the spectacular beauty and complexity of life.

The alternative hypothesis, that it was all started by a supernatural creator, is not only superfluous, it is also highly improbable. It falls foul of the very argument that was originally put forward in its favour. This is because any God worthy of the name must have been a being of colossal intelligence, a supermind, an entity of extremely low probability--a very improbable being indeed.

Even if the postulation of such an entity explained anything (and we don't need it to), it still wouldn't help because it raises a bigger mystery than it solves.

Science offers us an explanation of how complexity (the difficult) arose out of simplicity (the easy). The hypothesis of God offers no worthwhile explanation for anything, for it simply postulates what we are trying to explain. It postulates the difficult to explain, and leaves it at that. We cannot prove that there is no God, but we can safely conclude the He is very, very improbable indeed.

This was a lecture by Richard Dawkins extracted from The Nullifidian (Dec 94)

The noted Oxford scientist takes issue with the Chancellor on his view of Oxford 'elitism'

Dear Mr Brown

As Chancellor you surely formulate your policies in the light of meticulously researched statistical facts and figures. Yet this week you behaved like a Chancellor who is informed by a single shopper that the price of Woodbines is a bleeding liberty, believes it, and bases an important part of his budgetary policy on it. This week you have listened to tabloid tittle-tattle; you have used it to make political cheap shots; and above all you refused to climb down even when you had passed the point where you must have known you were mistaken.

The facts are these. Medicine is a notoriously over-subscribed subject, and many superb candidates are routinely beaten by even more superb candidates. As Alan Ryan pointed out in The Guardian last week, that doesn't make them bad runners. They enter another race and next time may outrun the competition. The young woman at the centre of your fuss went in for another race, at Harvard, and this time she outran the competition. Good for her. It doesn't mean the original race was unfair. Of the 23 candidates for only five places to read medicine at Magdalen, 12 had GCSE scores at least as good as hers.

It was reported - and you swallowed it - that she won a 'scholarship' at Harvard. By now somebody will have told you 'scholarship' in this context refers to the ordinary means-tested financial assistance Harvard hands out to its students. It does not carry the connotations of honour we associate with 'Scholarship'.

Moreover, Harvard have not accepted her to read medicine. If she had applied to Oxford to read almost any other scientific subject than medicine she would almost certainly have got in. She might have won a scholarship. I mean a real scholarship trailing clouds of glory - except that Oxford gave up Entrance Scholarships some years ago on the grounds that they were too elitist.

In your bullying tactics, you have been unfair to those successful candidates who were accepted. Surely you must realise that in order to make way for your favoured candidate, one of those superbly qualified young people would have had to have been rejected.

I genuinely believe that Oxford is not elitist, and this is supported by the recent Teaching Quality Assessment, which awarded Oxford full marks for its entrance procedures. But, important as that is, it has been overtaken by the fact that a holder of one of the three great Offices of State has been shown to be so wrong, yet refuses to acknowledge it.

Here at Oxford, we teach students not to base generalisations on one anecdote. We also teach them to admit it if they are conclusively shown to be wrong. 'New' Labour? You'll be really new if you now depart from all political precedent and apologise.

Yours sincerely,

Richard Dawkins,

Charles Simonyi Professor of Public Understanding of Science, Oxford

The Real Romance in the Stars

By Richard Dawkins
Article in The Independent December 1995 Also found on the Astrological Association of Great Britian Web site: Click here

Astrology is neither harmless nor fun, and we should see it as an enemy of truth, says Richard Dawkins, author of 'The Selfish Gene'. Why, he asks, do so many of us indulge in these pre-Copernican dabblings which are nothing short of wicked fraud?

We should take astrology seriously. No, I don't mean we should believe in it. I am talking about fighting it seriously instead of humouring it as a piece of harmless fun. Frivolous tolerance, probably the dominant stance towards astrology among educated people who don't actually believe in it, ran right through a recent article in the Independent on Sunday by Justine Picardie, "Spinning after Patric's Star". As the headline writer put it, "Astrology has never been so popular, or such big business. But when the late, great (sic) Patric Walker (Libra) died, it wasn't just his billion readers - or his income - that attracted his aspirant successors; it was his reputation as the Henry James of horoscope writers, as the man who'd made the trade respectable."

Hardly respectable, but surely something must be going on when even the Independent on Sunday can devote two pages plus a double picture spread to the question of who would inherit the mantle of a dead charlatan. Picardie's attitude to these well-heeled quacks ranges from affection (the Queen Mother's favourite astrologer is "roly poly") to something perilously near respect (Patric Walker is described without irony as "eminent") Respect might indeed be prompted by the wealth of these glitzy con-artists, which is lovingly dwelt upon (Chauffeurs whisk them in white stretch limos to fashionable restaurants where head waiters fawn over them).

The popular scientist David Belamy, who ought to know better and probably does, contributed to Patric Walker's astrology page in Radio Times, writing that he has the "Capricorn caution" over certain things, but mostly he puts his head down and charges like a real goat. Such shallow light-heartedness sets a mood in which questioning astrology's validity is made to seem pedantic Gradgrindery. To ask whether the astrologers themselves believe in it also comes over as a bit long-faced, on the killjoy side. On Picardie's evidence, some are foolish enough to believe anything (One of them met Patric Walker "just before Mercury went retrograde" and immediately recognised him "from a past life"). The roly-poly one sounds a bit more fly and may understand exactly what he's doing, but it is hard to penetrate his high-camp posturing. Mystic Meg by all accounts could be the best of the bunch, an old fashioned crystal-ball toter, showing up the pretensions of the others, which is presumably why they try to disown her.

The serious newspapers seem to be embarking on a self-conscious flirtation with astrology. Until recently they had nothing to do with such tabloid stuff. Then the Sunday Times succumbed and introduced its own astrology column, presumably with the excuse that it was just a bit of a giggle. The others haven't yet stooped so low, but some are acknowledging the pressure in more subtle ways. For the article by Justine Picardie the ostensible excuse was a story about financial success and succession. The same writer, incidentally, has followed it with an article on angels, again humorously open-minded ("There's this thing called going down in spirit"), teetering on the brink of outright respect for the lucrative profession of "angelologist" - one of them is an "eminent". Sorbonne professor of "philosophy" (which turns out to mean the usual "cultural studies" metatwaddle). There's this thing called being so open-minded your brains drop out.

This year-end the Guardian commissioned various individuals to look ahead to the future. Tucked away among some real scientists, historians and philosophers is none other than our roly-poly friend, the "First astrologer to play Nostradamus on TV". Here are his expert views: "On 12 January, Uranus moves into Aquarius and it's the dawning of a new age. It will be altruistic, humanitarian, brotherhood of man. I'm really looking forward to this. The energy (he obviously doesn't understand what this technical term means) will last until November 2008 because Uranus will be eight years in Aquarius and Pluto 13 years in Sagittarius. Thank God I'm Aquarius". And lots more in the same vein, which the Guardian considered fit to print. The Princess of Wales, herself an enthusiast for astrology as one might expect, has "got her Moon in Aquarius" and so has Tony Blair. "Could he do for the country what Di has done for the monarchy?" I have a better question. Why does a decent newspaper hand out free publicity to this phoney? Just a giggle, again? Or is the Guardian bending over backwards not to be elitist?

On a moonless night when the only clouds to be seen are the Magellanic Clouds of the Milky Way, go out to a place far from street light pollution, lie on the grass and gaze out at the stars.[1] What are you seeing? Superficially you notice constellations, but a constellation is of no more significance than a patch of curiously shaped damp on the bathroom ceiling. Note, accordingly, how little it means to say something like "Uranus moves into Aquarius". Aquarius is a miscellaneous set of stars all at different distances from us, which have no connection with each other except that they constitute a (meaningless) pattern when seen from a certain (not particularly special) place in the galaxy (here). A constellation is not an entity at all, not the kind of thing that Uranus, or anything else, can sensibly be said to "move into".

The shape of a constellation, moreover, is ephemeral. A million years ago our Homo erectus ancestors gazed out nightly (no light pollution then, unless it came from that species' brilliant innovation, the camp fire) at a set of very different constellations. A million years hence, our descendants will see yet other shapes in the sky, and their astrologer (if our species has not grown up and sent them packing long since) will be fabricating their oracles on the basis of a different zodiac.

A far more rapid astronomical shift is the precession of the equinoxes.[2] My birthday (26 March) is listed in the papers as Aries but this is the sun sign which somebody with my birthday would have had when Ptolemy codified all that stuff. Because of the precessional shift of approximately one whole zodiacal sign over the AD era, my sun sign is in fact (if you can call it a fact) Pisces. If astrologers were doing something that had any connection with reality, this presumably ought to make a difference. Since they aren't, it doesn't. Scorpio could go retrograde up Uranus and it wouldn't make any difference.

Actually, of course, only planets can "go retrograde", and even then it is an illusion. As they, and we, orbit the sun, planets will on occasion appear to reverse their direction from our point of view. But these occasions have no significance. From a third planet they would be seen to "go retrograde" at different times. Planets do not really "wander", and certainly not remotely near any constellation, which are the distant backdrops of our viewpoint. Even if "going retrograde" or "moving into Aquarius" were real phenomena, some thing that planets actually do, what influence could they possibly have on human events? A planet is so far away that its gravitational pull on a new-born baby would be swamped by the pull of the doctor's paunch.[3]

No, we can forget planets going retrograde, and we can forget constellations except as a convenient way of finding our way around. What else are we seeing when we gaze up at the night sky? One thing we are seeing is history. When you look at the great galaxy in Andromeda you are seeing it as it was 2.3 million years ago and Australopithecus stalked the African savannah. You are looking back in time. Shift your gaze a few degrees to the nearest bright star in the constellation of Andromeda and you are seeing Mirach, but much more recently, as it was when Wall Street crashed. The sun, when you see it, is only eight minutes ago. But look through a large telescope at the sombrero Galaxy and you are seeing a trillion suns as they were when your tailed ancestors peered shyly through the canopy and India collided with Asia to raise the Himalayas. A collision on a larger scale, between two galaxies in Stephan's Quintet, is shown to us at a time when on Earth dinosaurs were dawning and the trilobites fresh dead.

Name any year in history and there will be a star up there whose light gives you a glimpse of something happening that very year. Whatever the year of your birth, somewhere up in the night sky you could find your birth star (or stars, for the number is proportional to the third power of your age). Its light enables you to look back and see a thermonuclear glow that heralds your birth. A pleasing conceit, but that is all. Your birth star will not deign to tell anything about your personality, your future or your sexual compatibilities. The stars have larger agendas, in which the preoccupation's of human pettiness do not figure.

Your birth star, of course, is yours for only this year. Next year you must look to another shell of stars, one light year more distant. Think of this expanding bubble as a radius of good news, the news of you birth, broadcast steadily outwards. In the Einsteinian universe in which most physicists now think we live, nothing can in principle travel faster than light. So, if you are 50 years old, you have a personal news sphere of 50 light years radius. Within that sphere it is in principle possible (obviously not in practice) for news of your existence to have permeated. Outside that sphere you might as well not exist - in an Einsteinian sense you do not exist. Older people have larger existence spheres than younger people, but nobody's existence sphere extends to more than a tiny fraction of the universe. The birth of Jesus may seem an ancient and momentous event to us. But the news of it is actually so recent that, even in the most theoretically ideal circumstances, it could in principle have been proclaimed to less than one 200-million-millionth of the stars in the universe. Many, if not most, of the stars out there will be orbited by planets. The numbers are so vast that probably some of them have life forms, some have evolved intelligence and technology. Yet the distance and times that separate us are so great that thousands of life forms could independently evolve and go extinct without it being possible for any to know of the existence of any other. The real universe has mystery enough to need no help from obscurantist hucksters.

Scientific truth is too beautiful to be sacrificed for the sake of light entertainment or money. Astrology is an aesthetic affront. It cheapens astronomy, like using Beethoven for commercial jingles. By existing law neither Beethoven nor nature can sue, but perhaps existing law could be changed. If the methods of Astrologers were really shown to be valid it would be a fact of signal importance for science. Under such circumstances astrology should be taken seriously indeed. But if - as all indications agree - there is not a smidgen of validity in any of the things that astrologers so profitably do, this, too, should be taken seriously and not indulgently trivialised. We should learn to see the debauching of science for profit as a crime.

I must make the usual defence against a charge of scientific arrogance. How do I know that there is no truth in astrology? Well, of course I don't know. I can't prove that there is nothing in horoscopes, any more than I can prove that there is nothing in the (rather more plausible) theory that chewing gum causes mad cow disease. There just isn't any evidence in favour (of either theory), and no reason why we should expect there to be evidence. It isn't as though it would be difficult to find evidence for astrology, if there were any to be had. It wouldn't take anything like that blissful cartoon in which a newsreader announces: "In a major breakthrough for the science of astrology, all people born under Scorpio were yesterday run over by egg lorries."4 A statistical tendency, however slight, for people's personalities to be predictable from their birthdays, over and above the expected difference between winter and summer babies, would be a promising start.

For us to take a hypothesis seriously, it should ideally be supported by at least a little bit of evidence. If this is too much to ask, there should be some suggestion of a reason why it might be worth bothering to look for evidence. Graphology, as a means of reading personalities, is not supported by evidence either, but here the possibility that it might work is not hopelessly implausible a priori. The brain is the seat of the personality and the brain controls handwriting, so it is not in principle unlikely that style of handwriting might betray personality. It seems almost a pity that no good evidence has been forthcoming. But astrology has nothing going for it at all, neither evidence nor any inkling of a rationale which might prompt us to look for evidence. Astrology not only demeans astronomy, shrivelling and cheapening the universe with its pre Copernican dabblings. It is also an insult to the science of psychology and the richness of human personality. I am talking about the facile and potentially damaging way in which astrologers divide humans into 12 categories. Scorpios are cheerful, outgoing types, Leos with their methodical personalities go well with Libra's (or whatever it is). My wife, Lalla Ward, recalls an occasion when a more than usually brainless hanger-on approached the director of the film they were working on with a "Gee, Mr Preminger, what sign are you?" and received the immortal rebuff, "I am a do-not-disturb sign." We love an opportunity to pigeonhole each other but we should resist the temptation. Are you an introvert or an extrovert? Does your body shape betray an endomorphic, a mesomorphic or an ectomorphic personality? "The ectomorph is much more of an introvert and more shrewd and calculating".

Personality is a real phenomenon and psychologists (real, scientific psychologists, not Freudians or Jungians) have had some success in developing mathematical models to handle many dimensions of personality variation. The initially large number of dimensions can be mathematically collapsed into fewer dimensions with measurable, and for some purposes conscionable, loss in predictive power. These fewer derived dimensions sometimes correspond to the dimensions that we intuitively think we recognise - aggressiveness, obstinacy, affectionateness and so on. Summarising an individual's personality as a point in multidimensional space is a serviceable approximation whose limitations can be measured and are known. It is a far cry from any mutually exclusive categorisation, certainly far from the preposterous fiction of astrology's 12 dumpbins. It is based upon genuinely relevant data about people themselves, not their birthdays. The psychologist's multidimensional scaling can be useful in deciding whether a person is suited to a particular career, or a couple to each other. The astrologer's 12 pigeonholes are, if nothing worse, a costly and irrelevant distraction. Lonely hearts advertisers frequently insert astrological references alongside relevant information such as musical tastes or sporting interests, and may even insist that the partner they are looking for must be, for instance, Taurus. Think of what this means. The whole point of advertising in such columns is to increase the catchment area for meeting sexual partners (and indeed the circle provided by the workplace and by friends of friends is meagre and needs enriching). It is nothing short of ludicrous then to go out of your way to divide the available number of potential partners by twelve. Lonely people, whose life might be transformed by a longed for compatible friendship, are deliberately encouraged, by their reading of astrological quacks in the newspapers, wantonly and pointlessly to throw away 11/12ths of the available population. This is not just silly, it is damaging, and the quacks concerned deserve our censure as strongly as their deluded victims deserve our pity.

There are some stupid people out there, and they should be pitied not exploited. On a famous occasion a few years ago a newspaper hack, who had drawn the short straw and been told to make up the day's astrological advice, relieved his boredom by writing under one star sign the following portentous lines: "All the sorrows of yesteryear are as nothing compared to what will befall you today." He was fired after the switchboard was jammed with panic-stricken readers, pathetic testimony to the simple trust people can place in astrology.

The American conjuror James Randi recounts in his book Flim Flam how as a young man he briefly got the astrology job on a Montreal newspaper, making up the horoscopes under the name Zo-ran. His method was to cut out the forecasts from old astrology magazines, shuffle them in a hat, distribute them at random among the 12 zodiacal signs and print the results. This was very successful of course (because all astrology works on the "Barnum principle" of saying things so vague and general that all readers think it applies to them.) He describes how he overheard in a cafe a pair of office workers eagerly scanning Zo-ran's column in the paper. "They squealed with delight on seeing their future so well laid out, and in response to my query said that Zo-ran had been 'right smack on' last week. I did not identify myself as Zo-ran... Reaction in the mail to the column had been quite interesting, too, and sufficient for me to decide that many people will accept and rationalise almost any pronouncement made by someone they believe to be an authority with mystic powers. At this point, Zo-ran hung up his scissors, put away the paste pot, and went out of business.""

My case is that Randi was morally right to hang up his scissors, that serious newspapers should never give named astrologers the oxygen of publicity, that astrology is neither harmless nor fun, and that we should fight it seriously as an enemy of truth. We have a Trade Descriptions Act which protects us from manufacturers making false claims for their products. The law has not so far been invoked in defence of simple, scientific truth. Why not? Astrologers provide as good a test case as could be desired. They make claims to forecast the future, and they take payment for this, as well as for professional advice to individuals on important decisions. A pharmaceuticals manufacturer who marketed a birth-control pill that had not the slightest demonstrable effect upon fertility would be prosecuted under the Trade Descriptions Act, and sued by trusting customers who found themselves pregnant. If astrologers cannot be sued by individuals misadvised, say, into taking disastrous business decisions, why at least are they not prosecuted for false representation under the Trade Descriptions Act and driven out of business? Why, actually, are professional astrologers not jailed for fraud?

Notes

1. This is carrying poetic licence too far in a Northern Hemisphere paper. The Magellanic Clouds are visible only in the Southern Hemisphere! R.D.

2. Many astrologers are aware of precession but, instead of updating their methods, they prefer the lazy escape of 'tropical astrology' in which one uses zodiacal constellations as labels for the patch of sky where they would have appeared years ago. R.D.

3. The physics here is more complicated than can be spelled out in a general article. Two influences could theoretically be involved, direct gravitational attraction and tidal effects. In terms of direct gravitational attractions (which obey Newton's Inverse Square Law), an average doctor would be outweighed by all but the most distant members of the solar system. Tidal effects are another matter and they are far more important. They amount to distortions of the earth's gravitational field and obey an inverse cube law, instead of the usual inverse square law. The doctor's body would have greater tidal effects on a new-born baby than any heavenly body (see I.W.Kelly, J.Rotton & R.Culver, 1985, The Skeptical Inquirer, Vol. 10, No.2, pp 129-143. R.D.

4. I am aware that this is a joke against `naive sun sign' astrology which is shunned by other astrologers. It is, of course, sun sign astrology's well-heeled practitioners in newspapers and on television that I am attacking as exploitative charlatans. If there is good evidence (i.e. better than the often quoted but non-robust Gauquelin attempt) that some other kinds of astrology work, well and good. I have to say that I'd be extremely surprised. R.D.

Richard Dawkins

It rapidly became clear to me that the most imaginative way of looking at evolution, and the most inspiring way of teaching it, was to say that it's all about the genes. It's the genes that, for their own good, are manipulating the bodies they ride about in. The individual organism is a survival machine for its genes.

Richard Dawkins is considered by his peers to be the ultimate ultra-Darwinist. He is also a gifted writer, who is known for his popularization of Darwinian ideas as well as for original thinking on evolutionary theory. He has invented telling metaphors that illuminate the Darwinian debate: His book The Selfish Gene argues that genes-molecules of DNA-are the fundamental units of natural selection, the "replicators." Organisms, including ourselves, are "vehicles," the packaging for "replicators." The success or failure of replicators is based on their ability to build successful vehicles. There is a complementarity in the relationship: vehicles propagate their replicators, not themselves; replicators make vehicles. In The Extended Phenotype, he goes beyond the body to the family, the social group, the architecture, the environment that animals create, and sees these as part of the phenotype-the embodiment of the genes. He also takes a Darwinian view of culture, exemplified in his invention of the "meme," the unit of cultural inheritance; memes are essentially ideas, and they, too, are operated on by natural selection.

RICHARD DAWKINS is an evolutionary biologist and the Charles Simonyi Professor For The Understanding Of Science at Oxford University; Fellow of New College; author of The Selfish Gene (1976), 2d ed. 1989), The Extended Phenotype (1982), The Blind Watchmaker (1986), River out of Eden (1995) (ScienceMasters Series), Climbing Mount Improbable (1996), and Unweaving the Rainbow (1998).

In his role as the Charles Simonyi Professor For The Understanding Of Science at Oxford University, Dawkins regularly talks to the public regarding his views on the wonders of science.On November 12th, 1996, he delievered the Richard Dimbleby Lecture on BBC1 Television in England, entitled "Science, Delusion and the Appetite for Wonder." (See below).

Further Reading:

"Science, Delusion, and the Appetite for Wonder: A Talk by Richard Dawkins on Edge

"A Survival Machine" in The Third Culture

The World of Richard Dawkins
The Unofficial Richard Dawkins Website with links to articles, papers and reviews (by John Catalano)

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"Some people object to Dawkins as being what I now call a greedy reductionist--that is, they think he's vastly obersimplifying, trying to get the job done with too few levels of explanation. Even though some version of that objection may be true, it's not a big deal. The algorithmic approach as Dawkins presents it is deliberately oversimple. But Dawkins leaves plenty of room for making it even more complex. He puts in plenty of warnings that he's giving you an oversimple version of it. The "greedy reductionist" complaint is a tempest in a teapot. Dawkins is not wrong--he's just been too optimistic sometimes."

Daniel C. Dennett

"Notions like Selfish Genes, memes, and extended phenotypes are powerful and exciting. They make me think differently. Unfortunately, I spend a lot of time arguing against people who have overinterpreted these ideas. They're too easily misunderstood as explaining more than they do. So you see, this Dawkins is a dangerous guy. Like Marx. Or Darwin."

W. Daniel Hillis

Thoughts on Cloning Humans
by Richard Dawkins

Published in London Evening Standard, 25th Feb 1997

Cloning already happens by accident; not particularly often, but often enough that we all know examples. Identical twins are true clones of each other, with the same genes. So, the new discovery just announced from Edinburgh can't be all that radical in its moral and ethical implications. Heaven's foundations don't quiver every time a pair of identical twins is born.

Nevertheless, two bees seem to be buzzing around in public bonnets. First, the new technique makes baby duplicates of an existing adult. We might, as it were, clone Stephen Hawking or Mother Teresa, and this is not the same thing as twins of the same age. Second, the spectre is raised of multiple clones, regiments of identical individuals marching by the thousand, in lockstep to a Brave New Millennium. Looked at in certain ways, both these notions can be made to seem unpleasant. Phalanxes of identical little Hitlers, goosestepping to the same genetic drum, is a thought so horrifying as to overshadow any lingering curiosity we might have over the final solution to the "nature or nurture" problem.

But do you whisper to yourself a secret confession? Wouldn't you love to be cloned? I've never admitted it before, but I think I would. This has nothing to do with vanity, with thinking that the world would be a better place if there was another one of me going on after I'm dead. It is pure curiosity. I know how I turned out having been born in the 1940s, schooled in the 1950s, come of age in the 1960s, and so on. I find it a personally riveting thought that I could watch a small copy of myself, fifty years younger and wearing a baseball hat instead of a solar topee, nurtured through the early decades of the twenty first century. Mightn't it feel almost like turning back your personal clock fifty years? And mightn't it be wonderful to advise your junior copy on where you went wrong, and how to do it better?

Are some people motivated by a watered down version of this feeling when they want to have ordinary children, by the approved method? Their trouble is that the duplication is watered down too. By sex. Your child may half resemble you, but it has half your spouse[1]s genes too. Wonderful as that is (depending on your view of your spouse), it is hardly the full clock-zeroing experience.

Anyway, that is self-indulgent fantasy. It is one thing to clone an ordinary, nice, harmless person like you or me; or somebody we'd all like to see more of, like David Attenborough. But isn't it more likely that, if cloning became practical politics, politics itself would rear its ugly head? Who is most likely to get himself cloned in practice, David Attenborough or Saddam Hussein: someone that we all admire, or a Rupert Murdoch who has nothing to commend him except power, influence and money?

Suppose society managed to outlaw general, free-for-all cloning of just anybody who could afford it. How might we then decide whom we'd like to clone? Nobody has come up with a good solution to the "playing God" problem (which arises, say, when there's a shortage of kidney machines, and doctors are accused of playing God when they have to choose whose is the most worthy life to save). Would cloning dilemmas lead us inexorably to yet another committee of the great and the good, chaired (who could doubt it?) by Baroness Warnock and including (of course) Rabbi Julia Neuberger?

Another problem: how would the baby itself feel about it? Would it be teased at school, tormented for its uniqueness? Undoubtedly the first cloned baby would feel unusual. It would have a birth mother who was no relation, an identical brother or sister who might be fifty years older, and genetic parents perhaps long dead and old enough to be its great grandparents. But the stigma of uniqueness is not a new problem, and it is not beyond our wit to solve it. It presumably arose for the first IVF babies, yet now they are no longer called "test tube babies" and we hardly know who is one and who is not.

I think we must beware of a reflex and unthinking antipathy to everything "unnatural". Certainly cloning is unnatural. We haven't bred without sex for perhaps a thousand million years. But unnatural isn't a necessary synonym for bad. It's unnatural to read books, or travel faster than we can run, or scuba-dive, or fly. It's unnatural to wear clothes, but we do. Indeed, the people most likely to be scandalised at the prospect of human cloning are the very people most outraged by lack of human clothing.

Cloning may be good and it may be bad. Probably it's a bit of both. The question must not be greeted with reflex hysteria but decided quietly, soberly and on its merits. We need less emotion and more thought.

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Trial by Jury

by Richard Dawkins. Published as "Three herring gull chicks . . . the reason juries don't work" in The Observer (London), Sunday November 16, 1997.

Trial by jury must be one of the most conspicuously bad good ideas anyone ever had. Its devisers can hardly be blamed. They lived before the principles of statistical sampling and experimental design had been worked out. They weren’t scientists. Let me explain using an analogy. And if, at the end, somebody objects to my argument on the grounds that humans aren’t herring gulls, I’ll have failed to get my point across.

Adult herring gulls have a bright yellow bill with a conspicuous red spot near the tip. Their babies peck at the red spot, which induces the parents to regurgitate food for them. Niko Tinbergen, Nobel-Prizewinning zoologist and my old maestro at Oxford, offered naive young chicks a range of cardboard dummy gull heads varying in bill and spot colour, and shape. For each colour, shape or combination, Tinbergen measured the preferences of the baby chicks by counting their pecks in a standard time. The idea was to discover whether naive gull chicks are born with a built-in preference for long yellow things with red spots. If so, this would suggest that genes equip the young birds with detailed prior knowledge of the world in which they are about to hatch – a world in which food comes out of adult herring gull beaks.

Never mind the reason for the research, and never mind the conclusions. Consider, instead, the methods you must use, and the pitfalls you must avoid, if you want to get a correct result in any such experiment. These turn out to be general principles which apply to human juries as strongly as to gull chicks.

First, you obviously must test more than one chick. It could be that some chicks are red-biased, others blue-biased, with no tendency for herring gull chicks in general to share the same favourite colour. So, by picking out a single chick, you are measuring nothing more than individual bias. It is no answer to this objection that our chick may have given hundreds more pecks to one colour than to the other. A chick might begin by choosing any old colour at random, but once he has chosen he gets ‘locked on’ to that colour and hammers away at it, giving the other colours no chance. The essential problem here is that successive pecks, however numerous, are not ‘independent data’.

So, we must test more than one chick. How many? Is two enough? No, nor is three, and now we must start to think statistically. To make it simple, suppose that in a particular experiment we are comparing only red spots versus blue spots, both on a yellow background, and always presented simultaneously. If we test just two chicks separately, suppose the first chick chooses red. It had a 50% chance of doing so, at random. Now the second chick also happens to choose red. Again, the odds were 50% that it would do so at random, even if it were colourblind. There’s a 50% chance that two randomly choosing chicks will agree (half of the four possibilities: red red, red blue, blue red, blue blue). Three chicks aren’t enough either. If you write down all the possibilities, you’ll find that there’s a 25% chance of a unanimous verdict, by luck alone. Twenty five percent, as the odds of reaching a conclusion for the wrong reason, is unacceptably large.

How about twelve good chicks and true? Now you’re talking. If twelve chicks are independently offered a choice between two alternatives, the odds that they will all reach the same verdict by chance alone are satisfyingly low, only one in 1024.

But now suppose that, instead of testing our twelve chicks independently, we test them as a group. We take a maelstrom of twelve cheeping chicks and lower into their midst a red spotted dummy and a blue spotted dummy, each fitted with an electrical device for automatically tallying pecks. And suppose that the collective of chicks registers 532 pecks at red and zero at blue. Does this massive disparity show that herring gull chicks, in general, prefer red? Absolutely not. The pecks are not independent data. Chicks could have a strong tendency to imitate one another (as well as imitate themselves in lock-on effects). If one chick just happened to peck at red first, others might copy him and the whole company of chicks join in a frenzy of imitative pecking. As a matter of fact this is precisely what domestic chicken chicks do, and gull chicks are very likely the same. Even if not, the principle remains that the data are not independent and the experiment is therefore invalid. The twelve chicks are strictly equivalent to a single chick, and their summed pecks amount to only a single independent result.

Turning to courts of law, why are twelve jurors preferred to a single judge? Not because they are wiser, more knowledgeable or more practised in the arts of reasoning. Certainly not, and with a vengeance. Think of the astronomical damages awarded by juries in footling libel cases. Think how juries bring out the worst in histrionic, gallery-playing lawyers. Twelve jurors are preferred to one judge only because they are more numerous. Letting a single judge decide a verdict would be like letting a single chick speak for the whole herring gull species. Twelve heads are better than one, because they represent twelve assessments of the evidence.

But for this argument to be valid, the twelve assessments really have to be independent. And of course they are not. Twelve men and women locked in a jury room are like our clutch of twelve gull chicks. Whether they actually imitate each other like chicks, they might. That is enough to invalidate the principle by which a jury might be preferred over a single judge.

In practice, as is well documented and as I remember from the three juries that it has been my misfortune to serve on, juries are massively swayed by one or two vocal individuals. There is also strong pressure to conform to a unanimous verdict, which further undermines the principle of independent data. Increasing the number of jurors doesn't help, or not much (and not at all in strict principle). What you have to increase is the number of independent verdict-reaching units.

Oddly enough, the bizarre American system of televising trials opens up a real possibility of improving the jury system. By the end of trials such as those of Louise Woodward or O.J.Simpson, literally thousands of people around the country have attended to the evidence as assiduously as the official jury. A mass phone-in might produce a fairer verdict than a jury. But unfortunately journalistic discussion, radio talk-shows, and ordinary gossip would violate the Principle of Independent Data and we'd be back where we started. The broadcasting of trials, in any case, has horrible consequences. In the wake of Louise Woodward's trial, the Internet seethes with ill-spelled and ungrammatical viciousness, the cheque-book journalists are queuing up, and the unfortunate Judge Zobel has had to change his telephone number and employ a bodyguard.

So, how can we improve the system? Should twelve jurors be locked in twelve isolation chambers and their opinions separately polled so that they constitute genuinely independent data? If it is objected that some would be too stupid or inarticulate to reach a verdict on their own, we are left wondering why such individuals are allowed on a jury at all. Perhaps there is something to be said for the collective wisdom that emerges when a group of twelve people thrash out a topic together, round a table. But this still leaves the principle of independent data unsatisfied.

Should all cases be tried by two separate juries? Or three? Or twelve? Too expensive, at least if each jury has twelve members. Two juries of six members, or three juries of four members, would probably be an improvement over the present system. But isn't there some way of testing the relative merits of such alternative options, or of comparing the merits of trial by jury versus trial by judge?

Yes, there is. I'll call it the Two Verdicts Concordance Test. It is based on the principle that, if a decision is valid, two independent shots at making it should yield the same result. Just for purposes of the test, we run to the expense of having two juries, listening to the same case and forbidden to talk to members of the other jury. At the end, we lock the two juries in two separate jury rooms and see if they reach the same verdict. If they don't, nothing can be proved beyond reasonable doubt, and this would cast reasonable doubt on the jury system itself.

To make the experimental comparison with Trial by Judge, we need two experienced judges to listen to the same case, and require them too to reach their separate verdicts without talking to each other. Whichever system, Trial by Jury or Trial by Judge, yields the higher score of agreements over a number of trials is the better system and might even be accredited for future use with some confidence.

Would you bet on two independent juries reaching the same verdict in the Louise Woodward case? Could you imagine even one other jury reaching the same verdict in the O.J.Simpson case? Two judges, on the other hand, seem to me rather likely to score well on the concordance test. And should I be charged with a serious crime here's how I want to be tried. If I know myself to be guilty, I'll go with the loose cannon of a jury, the more ignorant, prejudiced and capricious the better. But if I am innocent, and the ideal of multiple independent decision-takers is unavailable, please give me a judge. Preferably Judge Hiller Zobel.

Viruses of the Mind

by Richard Dawkins
Article in Free Inquiry Summer 1993 pg 34-41

The haven all memes depend on reaching is the human mind, but a human mind is itself an artifact created when memes restructure a human brain in order to make it a better habitat for memes. The avenues for entry and departure are modified to suit local conditions, and strengthened by various artificial devices that enhance fidelity and prolixity of replication: native Chinese minds differ dramatically from native French minds, and literate minds differ from illiterate minds. What memes provide in return to the organisms in which they reside is an incalculable store of advantages --- with some Trojan horses thrown in for good measure. . .

Daniel Dennett, Consciousness Explained

1 Duplication Fodder

A beautiful child close to me, six and the apple of her father's eye, believes that Thomas the Tank Engine really exists. She believes in Father Christmas, and when she grows up her ambition is to be a tooth fairy. She and her school-friends believe the solemn word of respected adults that tooth fairies and Father Christmas really exist. This little girl is of an age to believe whatever you tell her. If you tell her about witches changing princes into frogs she will believe you. If you tell her that bad children roast forever in hell she will have nightmares. I have just discovered that without her father's consent this sweet, trusting, gullible six-year-old is being sent, for weekly instruction, to a Roman Catholic nun. What chance has she?

A human child is shaped by evolution to soak up the culture of her people. Most obviously, she learns the essentials of their language in a matter of months. A large dictionary of words to speak, an encyclopedia of information to speak about, complicated syntactic and semantic rules to order the speaking, are all transferred from older brains into hers well before she reaches half her adult size. When you are pre-programmed to absorb useful information at a high rate, it is hard to shut out pernicious or damaging information at the same time. With so many mindbytes to be downloaded, so many mental codons to be replicated, it is no wonder that child brains are gullible, open to almost any suggestion, vulnerable to subversion, easy prey to Moonies, Scientologists and nuns. Like immune-deficient patients, children are wide open to mental infections that adults might brush off without effort.

DNA, too, includes parasitic code. Cellular machinery is extremely good at copying DNA. Where DNA is concerned, it seems to have an eagerness to copy, seems eager to be copied. The cell nucleus is a paradise for DNA, humming with sophisticated, fast, and accurate duplicating machinery.

Cellular machinery is so friendly towards DNA duplication that it is small wonder cells play host to DNA parasites --- viruses, viroids, plasmids and a riff-raff of other genetic fellow travelers. Parasitic DNA even gets itself spliced seamlessly into the chromosomes themselves. ``Jumping genes'' and stretches of ``selfish DNA'' cut or copy themselves out of chromosomes and paste themselves in elsewhere. Deadly oncogenes are almost impossible to distinguish from the legitimate genes between which they are spliced. In evolutionary time, there is probably a continual traffic from ``straight'' genes to ``outlaw,'' and back again (Dawkins, 1982). DNA is just DNA. The only thing that distinguishes viral DNA from host DNA is its expected method of passing into future generations. ``Legitimate'' host DNA is just DNA that aspires to pass into the next generation via the orthodox route of sperm or egg. ``Outlaw'' or parasitic DNA is just DNA that looks to a quicker, less cooperative route to the future, via a squeezed droplet or a smear of blood, rather than via a sperm or egg.

For data on a floppy disc, a computer is a humming paradise just as cell nuclei hum with eagerness to duplicate DNA. Computers and their associated disc and tape readers are designed with high fidelity in mind. As with DNA molecules, magnetized bytes don't literally ``want'' to be faithfully copied. Nevertheless, you can write a computer program that takes steps to duplicate itself. Not just duplicate itself within one computer but spread itself to other computers. Computers are so good at copying bytes, and so good at faithfully obeying the instructions contained in those bytes, that they are sitting ducks to self-replicating programs: wide open to subversion by software parasites. Any cynic familiar with the theory of selfish genes and memes would have known that modern personal computers, with their promiscuous traffic of floppy discs and e-mail links, were just asking for trouble. The only surprising thing about the current epidemic of computer viruses is that it has been so long in coming.

2 Computer Viruses: a Model for an Informational Epidemiology

Computer viruses are pieces of code that graft themselves into existing, legitimate programs and subvert the normal actions of those programs. They may travel on exchanged floppy disks, or over networks. They are technically distinguished from ``worms'' which are whole programs in their own right, usually traveling over networks. Rather different are ``Trojan horses,'' a third category of destructive programs, which are not in themselves self-replicating but rely on humans to replicate them because of their pornographic or otherwise appealing content. Both viruses and worms are programs that actually say, in computer language, ``Duplicate me.'' Both may do other things that make their presence felt and perhaps satisfy the hole-in-corner vanity of their authors. These side-effects may be ``humorous'' (like the virus that makes the Macintosh's built-in loudspeaker enunciate the words ``Don't panic,'' with predictably opposite effect); malicious (like the numerous IBM viruses that erase the hard disk after a sniggering screen-announcement of the impending disaster); political (like the Spanish Telecom and Beijing viruses that protest about telephone costs and massacred students respectively); or simply inadvertent (the programmer is incompetent to handle the low-level system calls required to write an effective virus or worm). The famous Internet Worm, which paralyzed much of the computing power of the United States on November 2, 1988, was not intended (very) maliciously but got out of control and, within 24 hours, had clogged around 6,000 computer memories with exponentially multiplying copies of itself.

``Memes now spread around the world at the speed of light, and replicate at rates that make even fruit flies and yeast cells look glacial in comparison. They leap promiscuously from vehicle to vehicle, and from medium to medium, and are proving to be virtually unquarantinable'' (Dennett 1990, p.131). Viruses aren't limited to electronic media such as disks and data lines. On its way from one computer to another, a virus may pass through printing ink, light rays in a human lens, optic nerve impulses and finger muscle contractions. A computer fanciers' magazine that printed the text of a virus program for the interest of its readers has been widely condemned. Indeed, such is the appeal of the virus idea to a certain kind of puerile mentality (the masculine gender is used advisedly), that publication of any kind of ``how to'' information on designing virus programs is rightly seen as an irresponsible act.

I am not going to publish any virus code. But there are certain tricks of effective virus design that are sufficiently well known, even obvious, that it will do no harm to mention them, as I need to do to develop my theme. They all stem from the virus's need to evade detection while it is spreading.

A virus that clones itself too prolifically within one computer will soon be detected because the symptoms of clogging will become too obvious to ignore. For this reason many virus programs check, before infecting a system, to make sure that they are not already on that system. Incidentally, this opens the way for a defense against viruses that is analogous to immunization. In the days before a specific anti-virus program was available, I myself responded to an early infection of my own hard disk by means of a crude ``vaccination.'' Instead of deleting the virus that I had detected, I simply disabled its coded instructions, leaving the ``shell'' of the virus with its characteristic external ``signature'' intact. In theory, subsequent members of the same virus species that arrived in my system should have recognized the signature of their own kind and refrained from trying to double-infect. I don't know whether this immunization really worked, but in those days it probably was worth while ``gutting'' a virus and leaving a shell like this, rather than simply removing it lock, stock and barrel. Nowadays it is better to hand the problem over to one of the professionally written anti-virus programs.

A virus that is too virulent will be rapidly detected and scotched. A virus that instantly and catastrophically sabotages every computer in which it finds itself will not find itself in many computers. It may have a most amusing effect on one computer ---- erase an entire doctoral thesis or something equally side-splitting --- but it won't spread as an epidemic.

Some viruses, therefore, are designed to have an effect that is small enough to be difficult to detect, but which may nevertheless be extremely damaging. There is one type, which, instead of erasing disk sectors wholesale, attacks only spreadsheets, making a few random changes in the (usually financial) quantities entered in the rows and columns. Other viruses evade detection by being triggered probabilistically, for example erasing only one in 16 of the hard disks infected. Yet other viruses employ the time-bomb principle. Most modern computers are ``aware'' of the date, and viruses have been triggered to manifest themselves all around the world, on a particular date such as Friday 13th or April Fool's Day. From the parasitic point of view, it doesn't matter how catastrophic the eventual attack is, provided the virus has had plenty of opportunity to spread first (a disturbing analogy to the Medawar/Williams theory of ageing: we are the victims of lethal and sub-lethal genes that mature only after we have had plenty of time to reproduce (Williams, 1957)). In defense, some large companies go so far as to set aside one ``miner's canary'' among their fleet of computers, and advance its internal calendar a week so that any time-bomb viruses will reveal themselves prematurely before the big day.

Again predictably, the epidemic of computer viruses has triggered an arms race. Anti-viral software is doing a roaring trade. These antidote programs -- ``Interferon,'' ``Vaccine,'' ``Gatekeeper'' and others --- employ a diverse armory of tricks. Some are written with specific, known and named viruses in mind. Others intercept any attempt to meddle with sensitive system areas of memory and warn the user.

The virus principle could, in theory, be used for non-malicious, even beneficial purposes. Thimbleby (1991) coins the phrase ``liveware'' for his already-implemented use of the infection principle for keeping multiple copies of databases up to date. Every time a disk containing the database is plugged into a computer, it looks to see whether there is already another copy present on the local hard disk. If there is, each copy is updated in the light of the other. So, with a bit of luck, it doesn't matter which member of a circle of colleagues enters, say, a new bibliographical citation on his personal disk. His newly entered information will readily infect the disks of his colleagues (because the colleagues promiscuously insert their disks into one another's computers) and will spread like an epidemic around the circle. Thimbleby's liveware is not entirely virus-like: it could not spread to just anybody's computer and do damage. It spreads data only to already-existing copies of its own database; and you will not be infected by liveware unless you positively opt for infection.

Incidentally, Thimbleby, who is much concerned with the virus menace, points out that you can gain some protection by using computer systems that other people don't use. The usual justification for purchasing today's numerically dominant computer is simply and solely that it is numerically dominant. Almost every knowledgeable person agrees that, in terms of quality and especially user-friendliness, the rival, minority system is superior. Nevertheless, ubiquity is held to be good in itself, sufficient to outweigh sheer quality. Buy the same (albeit inferior) computer as your colleagues, the argument goes, and you'll be able to benefit from shared software, and from a generally large circulation of available software. The irony is that, with the advent of the virus plague, ``benefit'' is not all that you are likely to get. Not only should we all be very hesitant before we accept a disk from a colleague. We should also be aware that, if we join a large community of users of a particular make of computer, we are also joining a large community of viruses --- even, it turns out, disproportionately larger.

Returning to possible uses of viruses for positive purposes, there are proposals to exploit the ``poacher turned gamekeeper'' principle, and ``set a thief to catch a thief.'' A simple way would be to take any of the existing anti-viral programs and load it, as a ``warhead,'' into a harmless self-replicating virus. From a ``public health'' point of view, a spreading epidemic of anti-viral software could be especially beneficial because the computers most vulnerable to malicious viruses --- those whose owners are promiscuous in the exchange of pirated programs --- will also be most vulnerable to infection by the healing anti-virus. A more penetrating anti-virus might --- as in the immune system --- ``learn'' or ``evolve'' an improved capacity to attack whatever viruses it encountered.

I can imagine other uses of the computer virus principle which, if not exactly altruistic, are at least constructive enough to escape the charge of pure vandalism. A computer company might wish to do market research on the habits of its customers, with a view to improving the design of future products. Do users like to choose files by pictorial icon, or do they opt to display them by textual name only? How deeply do people nest folders (directories) within one another? Do people settle down for a long session with only one program, say a word processors, or are they constantly switching back and forth, say between writing and drawing programs? Do people succeed in moving the mouse pointer straight to the target, or do they meander around in time-wasting hunting movements that could be rectified by a change in design?

The company could send out a questionnaire asking all these questions, but the customers that replied would be a biased sample and, in any case, their own assessment of their computer-using behavior might be inaccurate. A better solution would be a market-research computer program. Customers would be asked to load this program into their system where it would unobtrusively sit, quietly monitoring and tallying key-presses and mouse movements. At the end of a year, the customer would be asked to send in the disk file containing all the tallyings of the market-research program. But again, most people would not bother to cooperate and some might see it as an invasion of privacy and of their disk space.

The perfect solution, from the company's point of view, would be a virus. Like any other virus, it would be self-replicating and secretive. But it would not be destructive or facetious like an ordinary virus. Along with its self-replicating booster it would contain a market-research warhead. The virus would be released surreptitiously into the community of computer users. Just like an ordinary virus it would spread around, as people passed floppy disks and e-mail around the community. As the virus spread from computer to computer, it would build up statistics on users behavior, monitored secretly from deep within a succession of systems. Every now and again, a copy of the viruses would happen to find its way, by normal epidemic traffic, back into one of the company's own computers. There it would be debriefed and its data collated with data from other copies of the virus that had come ``home.''

Looking into the future, it is not fanciful to imagine a time when viruses, both bad and good, have become so ubiquitous that we could speak of an ecological community of viruses and legitimate programs coexisting in the silicosphere. At present, software is advertised as, say, ``Compatible with System 7.'' In the future, products may be advertised as ``Compatible with all viruses registered in the 1998 World Virus Census; immune to all listed virulent viruses; takes full advantage of the facilities offered by the following benign viruses if present...'' Word-processing software, say, may hand over particular functions, such as word-counting and string-searches, to friendly viruses burrowing autonomously through the text.

Looking even further into the future, whole integrated software systems might grow, not by design, but by something like the growth of an ecological community such as a tropical rain-forest. Gangs of mutually compatible viruses might grow up, in the same way as genomes can be regarded as gangs of mutually compatible genes (Dawkins, 1982). Indeed, I have even suggested that our genomes should be regarded as gigantic colonies of viruses (Dawkins, 1976). Genes cooperate with one another in genomes because natural selection has favored those genes that prosper in the presence of the other genes that happen to be common in the gene pool. Different gene pools may evolve towards different combinations of mutually compatible genes. I envisage a time when, in the same kind of way, computer viruses may evolve towards compatibility with other viruses, to form communities or gangs. But then again, perhaps not! At any rate, I find the speculation more alarming than exciting.

At present, computer viruses don't strictly evolve. They are invented by human programmers, and if they evolve they do so in the same weak sense as cars or aeroplanes evolve. Designers derive this year's car as a slight modification of last year's car, and then may, more or less consciously, continue a trend of the last few years --- further flattening of the radiator grill or whatever it may be. Computer virus designers dream up ever more devious tricks for outwitting the programmers of anti-virus software. But computer viruses don't --- so far --- mutate and evolve by true natural selection. They may do so in the future. Whether they evolve by natural selection, or whether their evolution is steered by human designers, may not make much difference to their eventual performance. By either kind of evolution, we expect them to become better at concealment, and we expect them to become subtly compatible with other viruses that are at the same time prospering in the computer community.

DNA viruses and computer viruses spread for the same reason: an environment exists in which there is machinery well set up to duplicate and spread them around and to obey the instructions that the viruses embody. These two environments are, respectively, the environment of cellular physiology and the environment provided by a large community of computers and data-handling machinery. Are there any other environments like these, any other humming paradises of replication?

3 The Infected Mind

I have already alluded to the programmed-in gullibility of a child, so useful for learning language and traditional wisdom, and so easily subverted by nuns, Moonies and their ilk. More generally, we all exchange information with one another. We don't exactly plug floppy disks into slots in one another's skulls, but we exchange sentences, both through our ears and through our eyes. We notice each other's styles of moving and dressing and are influenced. We take in advertising jingles, and are presumably persuaded by them, otherwise hard-headed businessmen would not spend so much money polluting the air with them.

Think about the two qualities that a virus, or any sort of parasitic replicator, demands of a friendly medium,. the two qualities that make cellular machinery so friendly towards parasitic DNA, and that make computers so friendly towards computer viruses. These qualities are, firstly, a readiness to replicate information accurately, perhaps with some mistakes that are subsequently reproduced accurately; and, secondly, a readiness to obey instructions encoded in the information so replicated.

Cellular machinery and electronic computers excel in both these virus-friendly qualities. How do human brains match up? As faithful duplicators, they are certainly less perfect than either cells or electronic computers. Nevertheless, they are still pretty good, perhaps about as faithful as an RNA virus, though not as good as DNA with all its elaborate proofreading measures against textual degradation. Evidence of the fidelity of brains, especially child brains, as data duplicators is provided by language itself. Shaw's Professor Higgins was able by ear alone to place Londoners in the street where they grew up. Fiction is not evidence for anything, but everyone knows that Higgins's fictional skill is only an exaggeration of something we can all do. Any American can tell Deep South from Mid West, New England from Hillbilly. Any New Yorker can tell Bronx from Brooklyn. Equivalent claims could be substantiated for any country. What this phenomenon means is that human brains are capable of pretty accurate copying (otherwise the accents of, say, Newcastle would not be stable enough to be recognized) but with some mistakes (otherwise pronunciation would not evolve, and all speakers of a language would inherit identically the same accents from their remote ancestors). Language evolves, because it has both the great stability and the slight changeability that are prerequisites for any evolving system.

The second requirement of a virus-friendly environment --- that it should obey a program of coded instructions --- is again only quantitatively less true for brains than for cells or computers. We sometimes obey orders from one another, but also we sometimes don't. Nevertheless, it is a telling fact that, the world over, the vast majority of children follow the religion of their parents rather than any of the other available religions. Instructions to genuflect, to bow towards Mecca, to nod one's head rhythmically towards the wall, to shake like a maniac, to ``speak in tongues'' --- the list of such arbitrary and pointless motor patterns offered by religion alone is extensive --- are obeyed, if not slavishly, at least with some reasonably high statistical probability.

Less portentously, and again especially prominent in children, the ``craze'' is a striking example of behavior that owes more to epidemiology than to rational choice. Yo-yos, hula hoops and pogo sticks, with their associated behavioral fixed actions, sweep through schools, and more sporadically leap from school to school, in patterns that differ from a measles epidemic in no serious particular. Ten years ago, you could have traveled thousands of miles through the United States and never seen a baseball cap turned back to front. Today, the reverse baseball cap is ubiquitous. I do not know what the pattern of geographical spread of the reverse baseball cap precisely was, but epidemiology is certainly among the professions primarily qualified to study it. We don't have to get into arguments about ``determinism''; we don't have to claim that children are compelled to imitate their fellows' hat fashions. It is enough that their hat-wearing behavior, as a matter of fact, is statistically affected by the hat-wearing behavior of their fellows.

Trivial though they are, crazes provide us with yet more circumstantial evidence that human minds, especially perhaps juvenile ones, have the qualities that we have singled out as desirable for an informational parasite. At the very least the mind is a plausible candidate for infection by something like a computer virus, even if it is not quite such a parasite's dream-environment as a cell nucleus or an electronic computer.

It is intriguing to wonder what it might feel like, from the inside, if one's mind were the victim of a ``virus.'' This might be a deliberately designed parasite, like a present-day computer virus. Or it might be an inadvertently mutated and unconsciously evolved parasite. Either way, especially if the evolved parasite was the memic descendant of a long line of successful ancestors, we are entitled to expect the typical ``mind virus'' to be pretty good at its job of getting itself successfully replicated.

Progressive evolution of more effective mind-parasites will have two aspects. New ``mutants'' (either random or designed by humans) that are better at spreading will become more numerous. And there will be a ganging up of ideas that flourish in one another's presence, ideas that mutually support one another just as genes do and as I have speculated computer viruses may one day do. We expect that replicators will go around together from brain to brain in mutually compatible gangs. These gangs will come to constitute a package, which may be sufficiently stable to deserve a collective name such as Roman Catholicism or Voodoo. It doesn't too much matter whether we analogize the whole package to a single virus, or each one of the component parts to a single virus. The analogy is not that precise anyway, just as the distinction between a computer virus and a computer worm is nothing to get worked up about. What matters is that minds are friendly environments to parasitic, self-replicating ideas or information, and that minds are typically massively infected.

Like computer viruses, successful mind viruses will tend to be hard for their victims to detect. If you are the victim of one, the chances are that you won't know it, and may even vigorously deny it. Accepting that a virus might be difficult to detect in your own mind, what tell-tale signs might you look out for? I shall answer by imaging how a medical textbook might describe the typical symptoms of a sufferer (arbitrarily assumed to be male).

1. The patient typically finds himself impelled by some deep, inner conviction that something is true, or right, or virtuous: a conviction that doesn't seem to owe anything to evidence or reason, but which, nevertheless, he feels as totally compelling and convincing. We doctors refer to such a belief as ``faith.''

2. Patients typically make a positive virtue of faith's being strong and unshakable, in spite of not being based upon evidence. Indeed, they may feel that the less evidence there is, the more virtuous the belief (see below).

This paradoxical idea that lack of evidence is a positive virtue where faith is concerned has something of the quality of a program that is self-sustaining, because it is self-referential (see the chapter ``On Viral Sentences and Self-Replicating Structures'' in Hofstadter, 1985). Once the proposition is believed, it automatically undermines opposition to itself. The ``lack of evidence is a virtue'' idea could be an admirable sidekick, ganging up with faith itself in a clique of mutually supportive viral programs.

3. A related symptom, which a faith-sufferer may also present, is the conviction that ``mystery,'' per se, is a good thing. It is not a virtue to solve mysteries. Rather we should enjoy them, even revel in their insolubility.

Any impulse to solve mysteries could be serious inimical to the spread of a mind virus. It would not, therefore, be surprising if the idea that ``mysteries are better not solved'' was a favored member of a mutually supporting gang of viruses. Take the ``Mystery of Transubstantiation.'' It is easy and non-mysterious to believe that in some symbolic or metaphorical sense the eucharistic wine turns into the blood of Christ. The Roman Catholic doctrine of transubstantiation, however, claims far more. The ``whole substance'' of the wine is converted into the blood of Christ; the appearance of wine that remains is ``merely accidental,'' ``inhering in no substance'' (Kenny, 1986, p. 72). Transubstantiation is colloquially taught as meaning that the wine ``literally'' turns into the blood of Christ. Whether in its obfuscatory Aristotelian or its franker colloquial form, the claim of transubstantiation can be made only if we do serious violence to the normal meanings of words like ``substance'' and ``literally.'' Redefining words is not a sin, but, if we use words like ``whole substance'' and ``literally'' for this case, what word are we going to use when we really and truly want to say that something did actually happen? As Anthony Kenny observed of his own puzzlement as a young seminarian, ``For all I could tell, my typewriter might be Benjamin Disraeli transubstantiated....''

Roman Catholics, whose belief in infallible authority compels them to accept that wine becomes physically transformed into blood despite all appearances, refer to the ``mystery'' of transubstantiation. Calling it a mystery makes everything OK, you see. At least, it works for a mind well prepared by background infection. Exactly the same trick is performed in the ``mystery'' of the Trinity. Mysteries are not meant to be solved, they are meant to strike awe. The ``mystery is a virtue'' idea comes to the aid of the Catholic, who would otherwise find intolerable the obligation to believe the obvious nonsense of the transubstantiation and the ``three-in-one.'' Again, the belief that ``mystery is a virtue'' has a self-referential ring. As Hofstadter might put it, the very mysteriousness of the belief moves the believer to perpetuate the mystery.

An extreme symptom of ``mystery is a virtue'' infection is Tertullian's ``Certum est quia impossibile est'' (It is certain because it is impossible''). That way madness lies. One is tempted to quote Lewis Carroll's White Queen, who, in response to Alice's ``One can't believe impossible things'' retorted ``I daresay you haven't had much practice... When I was your age, I always did it for half-an-hour a day. Why, sometimes I've believed as many as six impossible things before breakfast.'' Or Douglas Adams' Electric Monk, a labor-saving device programmed to do your believing for you, which was capable of ``believing things they'd have difficulty believing in Salt Lake City'' and which, at the moment of being introduced to the reader, believed, contrary to all the evidence, that everything in the world was a uniform shade of pink. But White Queens and Electric Monks become less funny when you realize that these virtuoso believers are indistinguishable from revered theologians in real life. ``It is by all means to be believed, because it is absurd'' (Tertullian again). Sir Thomas Browne (1635) quotes Tertullian with approval, and goes further: ``Methinks there be not impossibilities enough in religion for an active faith.'' And ``I desire to exercise my faith in the difficultest point; for to credit ordinary and visible objects is not faith, but perswasion [sic].''

I have the feeling that something more interesting is going on here than just plain insanity or surrealist nonsense, something akin to the admiration we feel when we watch a ten-ball juggler on a tightrope. It is as though the faithful gain prestige through managing to believe even more impossible things than their rivals succeed in believing. Are these people testing --- exercising --- their believing muscles, training themselves to believe impossible things so that they can take in their stride the merely improbable things that they are ordinarily called upon to believe?

While I was writing this, the Guardian (July 29, 1991) fortuitously carried a beautiful example. It came in an interview with a rabbi undertaking the bizarre task of vetting the kosher-purity of food products right back to the ultimate origins of their minutest ingredients. He was currently agonizing over whether to go all the way to China to scrutinize the menthol that goes into cough sweets. ``Have you ever tried checking Chinese menthol... it was extremely difficult, especially since the first letter we sent received the reply in best Chinese English, `The product contains no kosher'... China has only recently started opening up to kosher investigators. The menthol should be OK, but you can never be absolutely sure unless you visit.'' These kosher investigators run a telephone hot-line on which up-to-the-minute red-alerts of suspicion are recorded against chocolate bars and cod-liver oil. The rabbi sighs that the green-inspired trend away from artificial colors and flavors ``makes life miserable in the kosher field because you have to follow all these things back.'' When the interviewer asks him why he bothers with this obviously pointless exercise, he makes it very clear that the point is precisely that there is no point:

That most of the Kashrut laws are divine ordinances without reason given is 100 per cent the point. It is very easy not to murder people. Very easy. It is a little bit harder not to steal because one is tempted occasionally. So that is no great proof that I believe in God or am fulfilling His will. But, if He tells me not to have a cup of coffee with milk in it with my mincemeat and peaces at lunchtime, that is a test. The only reason I am doing that is because I have been told to so do. It is something difficult.

Helena Cronin has suggested to me that there may be an analogy here to Zahavi's handicap theory of sexual selection and the evolution of signals (Zahavi, 1975). Long unfashionable, even ridiculed (Dawkins, 1976), Zahavi's theory has recently been cleverly rehabilitated (Grafen, 1990 a, b) and is now taken seriously by evolutionary biologists (Dawkins, 1989). Zahavi suggests that peacocks, for instance, evolve their absurdly burdensome fans with their ridiculously conspicuous (to predators) colors, precisely because they are burdensome and dangerous, and therefore impressive to females. The peacock is, in effect, saying: ``Look how fit and strong I must be, since I can afford to carry around this preposterous tail.''

To avoid misunderstanding of the subjective language in which Zahavi likes to make his points, I should add that the biologist's convention of personifying the unconscious actions of natural selection is taken for granted here. Grafen has translated the argument into an orthodox Darwinian mathematical model, and it works. No claim is here being made about the intentionality or awareness of peacocks and peahens. They can be as sphexish or as intentional as you please (Dennett, 1983, 1984). Moreover, Zahavi's theory is general enough not to depend upon a Darwinian underpinning. A flower advertising its nectar to a ``skeptical'' bee could benefit from the Zahavi principle. But so could a human salesman seeking to impress a client.

The premise of Zahavi's idea is that natural selection will favor skepticism among females (or among recipients of advertising messages generally). The only way for a male (or any advertiser) to authenticate his boast of strength (quality, or whatever is is) is to prove that it is true by shouldering a truly costly handicap --- a handicap that only a genuinely strong (high quality, etc.) male could bear. It may be called the principle of costly authentication. And now to the point. Is it possible that some religious doctrines are favored not in spite of being ridiculous but precisely because they are ridiculous? Any wimp in religion could believe that bread symbolically represents the body of Christ, but it takes a real, red-blooded Catholic to believe something as daft as the transubstantiation. If you believe that you can believe anything, and (witness the story of Doubting Thomas) these people are trained to see that as a virtue.

Let us return to our list of symptoms that someone afflicted with the mental virus of faith, and its accompanying gang of secondary infections, may expect to experience.

4. The sufferer may find himself behaving intolerantly towards vectors of rival faiths, in extreme cases even killing them or advocating their deaths. He may be similarly violent in his disposition towards apostates

(people who once held the faith but have renounced it); or towards heretics (people who espouse a different --- often, perhaps significantly, only very slightly different --- version of the faith). He may also feel hostile towards other modes of thought that are potentially inimical to his faith, such as the method of scientific reason which may function rather like a piece of anti-viral software.

The threat to kill the distinguished novelist Salman Rushdie is only the latest in a long line of sad examples. On the very day that I wrote this, the Japanese translator of The Satanic Verses was found murdered, a week after a near-fatal attack on the Italian translator of the same book. By the way, the apparently opposite symptom of ``sympathy'' for Muslim ``hurt,'' voiced by the Archbishop of Canterbury and other Christian leaders (verging, in the case of the Vatican, on outright criminal complicity) is, of course, a manifestation of the symptom we discussed earlier: the delusion that faith, however obnoxious its results, has to be respected simply because it is faith.

Murder is an extreme, of course. But there is an even more extreme symptom, and that is suicide in the militant service of a faith. Like a soldier ant programmed to sacrifice her life for germ-line copies of the genes that did the programming, a young Arab or Japanese [??!] is taught that to die in a holy war is the quickest way to heaven. Whether the leaders who exploit him really believe this does not diminish the brutal power that the ``suicide mission virus'' wields on behalf of the faith. Of course suicide, like murder, is a mixed blessing: would-be converts may be repelled, or may treat with contempt a faith that is perceived as insecure enough to need such tactics.

More obviously, if too many individuals sacrifice themselves the supply of believers could run low. This was true of a notorious example of faith-inspired suicide, though in this case it was not ``kamikaze'' death in battle. The Peoples' Temple sect became extinct when its leader, the Reverend Jim Jones, led the bulk of his followers from the United States to the Promised Land of ``Jonestown'' in the Guyanan jungle where he persuaded more than 900 of them, children first, to drink cyanide. The macabre affair was fully investigated by a team from the San Francisco Chronicle (Kilduff and Javers, 1978).

Jones, ``the Father,'' had called his flock together and told them it was time to depart for heaven.
``We're going to meet,'' he promised, ``in another place.''
The words kept coming over the camp's loudspeakers.
``There is great dignity in dying. It is a great demonstration for everyone to die.''

Incidentally, it does not escape the trained mind of the alert sociobiologist that Jones, within his sect in earlier days, ``proclaimed himself the only person permitted to have sex'' (presumably his partners were also permitted). ``A secretary would arrange for Jones's liaisons. She would call up and say, `Father hates to do this, but he has this tremendous urge and could you please...?' '' His victims were not only female. One 17-year-old male follower, from the days when Jones's community was still in San Francisco, told how he was taken for dirty weekends to a hotel where Jones received a ``minister's discount for Rev. Jim Jones and son.'' The same boy said: ``I was really in awe of him. He was more than a father. I would have killed my parents for him.'' What is remarkable about the Reverend Jim Jones is not his own self-serving behavior but the almost superhuman gullibility of his followers. Given such prodigious credulity, can anyone doubt that human minds are ripe for malignant infection?

Admittedly, the Reverend Jones conned only a few thousand people. But his case is an extreme, the tip of an iceberg. The same eagerness to be conned by religious leaders is widespread. Most of us would have been prepared to bet that nobody could get away with going on television and saying, in all but so many words, ``Send me your money, so that I can use it to persuade other suckers to send me their money too.'' Yet today, in every major conurbation in the United States, you can find at least one television evangelist channel entirely devoted to this transparent confidence trick. And they get away with it in sackfuls. Faced with suckerdom on this awesome scale, it is hard not to feel a grudging sympathy with the shiny-suited conmen. Until you realize that not all the suckers are rich, and that it is often widows' mites on which the evangelists are growing fat. I have even heard one of them explicitly invoking the principle that I now identify with Zahavi's principle of costly authentication. God really appreciates a donation, he said with passionate sincerity, only when that donation is so large that it hurts. Elderly paupers were wheeled on to testify how much happier they felt since they had made over their little all to the Reverend whoever it was.

5. The patient may notice that the particular convictions that he holds, while having nothing to do with evidence, do seem to owe a great deal to epidemiology. Why, he may wonder, do I hold this set of

convictions rather than that set? Is it because I surveyed all the world's faiths and chose the one whose claims seemed most convincing? Almost certainly not. If you have a faith, it is statistically overwhelmingly likely that it is the same faith as your parents and grandparents had. No doubt soaring cathedrals, stirring music, moving stories and parables, help a bit. But by far the most important variable determining your religion is the accident of birth. The convictions that you so passionately believe would have been a completely different, and largely contradictory, set of convictions, if only you had happened to be born in a different place. Epidemiology, not evidence.

6. If the patient is one of the rare exceptions who follows a different religion from his parents, the explanation may still be epidemiological. To be sure, it is possible that he dispassionately surveyed the world's faiths and chose the most convincing one. But it is statistically more probable that he has been exposed to a particularly potent infective agent --- a John Wesley, a Jim Jones or a St. Paul. Here we are talking about horizontal transmission, as in measles. Before, the epidemiology was that of vertical transmission, as in Huntington's Chorea.

7. The internal sensations of the patient may be startlingly reminiscent of those more ordinarily associated with sexual love. This is an extremely potent force in the brain, and it is not surprising that some viruses have evolved to exploit it. St. Teresa of Avila's famously orgasmic vision is too notorious to need quoting again. More seriously, and on a less crudely sensual plane, the philosopher Anthony Kenny provides moving testimony to the pure delight that awaits those that manage to believe in the mystery of transubstantiation. After describing his ordination as a Roman Catholic priest, empowered by laying on of hands to celebrate Mass, he goes on that he vividly recalls

the exaltation of the first months during which I had the power to say Mass. Normally a slow and sluggish riser, I would leap early out of bed, fully awake and full of excitement at the thought of the momentous act I was privileged to perform. I rarely said the public Community Mass: most days I celebrated alone at a side altar with a junior member of the College to serve as acolyte and congregation. But that made no difference to the solemnity of the sacrifice or the validity of the consecration.
It was touching the body of Christ, the closeness of the priest to Jesus, which most enthralled me. I would gaze on the Host after the words of consecration, soft-eyed like a lover looking into the eyes of his beloved... Those early days as a priest remain in my memory as days of fulfilment and tremulous happiness; something precious, and yet too fragile to last, like a romantic love-affair brought up short by the reality of an ill-assorted marriage. (Kenny, 1986, pp. 101-2)

Dr. Kenny is affectingly believable that it felt to him, as a young priest, as though he was in love with the consecrated host. What a brilliantly successful virus! On the same page, incidentally, Kenny also shows us that the virus is transmitted contagiously --- if not literally then at least in some sense --- from the palm of the infecting bishop's hand through the top of the new priest's head:

If Catholic doctrine is true, every priest validly ordained derives his orders in an unbroken line of laying on of hands, through the bishop who ordains him, back to one of the twelve Apostles... there must be centuries-long, recorded chains of layings on of hands. It surprises me that priests never seem to trouble to trace their spiritual ancestry in this way, finding out who ordained their bishop, and who ordained him, and so on to Julius II or Celestine V or Hildebrand, or Gregory the Great, perhaps. (Kenny, 1986, p. 101)

It surprises me, too.

4 Is Science a Virus

No. Not unless all computer programs are viruses. Good, useful programs spread because people evaluate them, recommend them and pass them on. Computer viruses spread solely because they embody the coded instructions: ``Spread me.'' Scientific ideas, like all memes, are subject to a kind of natural selection, and this might look superficially virus-like. But the selective forces that scrutinize scientific ideas are not arbitrary and capricious. They are exacting, well-honed rules, and they do not favor pointless self-serving behavior. They favor all the virtues laid out in textbooks of standard methodology: testability, evidential support, precision, quantifiability, consistency, intersubjectivity, repeatability, universality, progressiveness, independence of cultural milieu, and so on. Faith spreads despite a total lack of every single one of these virtues.

You may find elements of epidemiology in the spread of scientific ideas, but it will be largely descriptive epidemiology. The rapid spread of a good idea through the scientific community may even look like a description of a measles epidemic. But when you examine the underlying reasons you find that they are good ones, satisfying the demanding standards of scientific method. In the history of the spread of faith you will find little else but epidemiology, and causal epidemiology at that. The reason why person A believes one thing and B believes another is simply and solely that A was born on one continent and B on another. Testability, evidential support and the rest aren't even remotely considered. For scientific belief, epidemiology merely comes along afterwards and describes the history of its acceptance. For religious belief, epidemiology is the root cause.

5 Epilogue

Happily, viruses don't win every time. Many children emerge unscathed from the worst that nuns and mullahs can throw at them. Anthony Kenny's own story has a happy ending. He eventually renounced his orders because he could no longer tolerate the obvious contradictions within Catholic belief, and he is now a highly respected scholar. But one cannot help remarking that it must be a powerful infection indeed that took a man of his wisdom and intelligence --- President of the British Academy, no less --- three decades to fight off. Am I unduly alarmist to fear for the soul of my six-year-old innocent?

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Article in The Indpendent Review September 11, 2002
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We asked 10 leading figures for their thoughts on the events of September 11 and its ramifications throughout the past year. Here are their responses.
Interviews by Clare Dwyer Hogg, Clare Rudbeck and Tom Phillips

Sue MacGregor, broadcaster

"A few weeks after the attacks, a close friend came to lunch. She is married to a Palestinian Arab. We skirted round the subject for a while, for I sensed, as did she, that her views might not be those of most of my other friends. 'Nothing has changed,' she said. 'Admit it – what's changed about your life? Nothing at all. Except that perhaps you understand why it happened.'

On one level she was right. My stomach had stopped lurching every time I saw a plane approach the Post Office tower from my local London park. I had stopped what I knew was a shameful thing – casting suspicious glances at every robed and bearded Muslim man I passed in the street. And yet of course the world has radically changed. The United States, under a president who seemed uninterested in the outside world, is now more heavily engaged in it than ever. Just as the disparate Muslim world has found new reasons to unite, so US citizens cling together under their "God Bless America" posters. A year after, we appear closer than ever to war, but no longer a war against a country harbouring large cells of al-Qa'ida militants.

It is a war against a nasty tyrant who still happens to be in power, a convenient target for some unfinished business. In covering the greatest story of the new century, the British media have seized their opportunities with, on the whole, commendable grace. There have been remarkable and moving press interviews, photographs and radio and TV documentaries telling almost unbearable tales of personal anguish. The world feels a fragile place, but on this evidence, courage and magnanimity are not in short supply. Thank goodness."

Eric Hobsbawm, historian

"I experienced September 11 in a hospital bed and consequently I was in the position a) of being able to watch it all the time and b) of seeing it as the typical, passive public. The pictures were extraordinary; one couldn't take one's eyes off them. They were followed by a wave of sound, most of which was a sort of sentimental hysteria. When it wasn't sentimental hysteria, it was meaningless and dangerous waffle: all this stuff about the world having changed because of the necessity to fight global terrorism.

As far as we were concerned, it was an appalling human tragedy. But it didn't change anything in the world situation. It did briefly humiliate the United States, but it wasn't a greater threat to the US. Most of Europe had learnt to live with terrorism for the past 30 years. The extraordinary thing is the reaction by the US, and it is this, rather than the actual events of September 11, that did change the world. The US used it as an opportunity for asserting that it can run the world. And it is still doing it."

Iqbal Sacranie, Secretary-General of the Muslim Council of Britain

"When I heard the news I was frozen with dread. The actions of the terrorists on September 11 were evil and indiscriminate. Following the experience of the Oklahoma bombing in 1995, when Muslims were wrongly suspected, I was certain there was going to be a lot of irresponsible speculation which could lead to harm being done to innocent Muslims. Sure enough, this backlash materialised in the form of hate-mail and attacks on mosques, Muslim cemeteries and assaults on British Muslims.

For me and many of my colleagues in the MCB, there is no such thing as family life any more; we are under so much pressure. It cannot be right that an entire civilisation is tarnished because of the actions of a few. Terrorism has no religion. We must not fall into the trap of responding with anger and hate. Our emphasis should be on justice, not vengeance. I am concerned at the direction in which the 'war on terror' seems to be heading. We are in danger of abandoning the course of international legality, and charting a new course based on brute force.

To avoid situations like this in future, we should try harder to build greater understanding between different cultures."

Roger Scruton, philosopher

"The principal thing that it has done is awoken people to the fact that the main threats to the world order now don't come necessarily from states but from private-enterprise terrorism of the al-Qa'ida kind. Thanks to the increased mobility of people around the world, and all the legal loopholes that have opened in order to facilitate this, terrorists have an open field. They can go anywhere and achieve just about anything, and there is no way of stopping them simply by threatening a state.

It has also brought into consciousness, at least among certain people, the value of having proper national sovereignty, as opposed to religious authority, as the principal source of law. The great problem of the Middle East is that there is no real sense of the legitimacy of the nation state; all legitimacy has to be traced ultimately back to religious law, which doesn't necessarily respect boundaries, and doesn't have an even-handed view of what territory is. The American system, by contrast, is the ultimate expression of the nation-state idea; that the law claims its validity from the people who are resident in a particular place, extending impartially to all who are citizens, regardless of their faith and so on. I think it has brought home to people the clash between two completely different conceptions of legitimacy. Unfortunately the nation state, the source of the only kind of legitimacy we really can live by, is under threat from Europe and the whole "globalising" process. All these things have been brought to our attention by September 11.

The initial response to that day was the intervention in Afghanistan, and that changed things for the better. It brought home to the Afghans how much better it is if they can achieve the national identity of the nation state they once had, instead of tribal and religious forms of conflict."

Susie Orbach, psychotherapist

"I think September 11 has changed the world profoundly. On the one hand, it's brought the West out of a kind of political amnesia; on the other, the US constructed the response in such a way that it's marked by demonisation and an untextured, unfruitful political conversation. It has been a psychologically very frightening moment, in which one needs the capacity to think very widely, think anew, challenge one's assumptions. And yet, in public discourse, the emphasis has been on collapsing difference, on moving away from subtlety.

There has been a reordering of America, with the US strutting its power, taking the events of September 11 to position itself – as it always has – as the country not subject to external threat. Since the attacks, this has become more explicit. September 11 has solved a lot of the US's internal problems. It has created unity and reinforced an illegitimate presidency. It is very frightening to see Britain in partnership with that.

This is not to say that people are not really concerned about Afghanistan or Iraq or the Middle East, or all those issues we ought to think hard about in order to come up with proposals that increase the possibility of managing conflict. But our response to them is different, it's more inadequate. I think that many people in Britain thought that, with the election of Bush, there would be a movement toward Europe, politically and economically. Ideologically, people are stunned by the automatic alliance with the US – not our emotional response, which is understandable, but our government's alliance with the US response to September 11: its push for war on Iraq and its minimal response to the Middle East situation.

It would also be crazy to pretend that there hasn't been an increase in racism. In this sense, the internal political situation in Britain is far more fraught."

JG Ballard, writer

"I'm not completely sure what I feel, partly because I can't help feeling that the Americans don't know what they feel. It was a frightening and horrific thing. The American response at the time – the invasion of Afghanistan, banishment of the Taliban, attack on all the al-Qa'ida bases – struck me as very impressive and measured. Now, things seem less sure – the Americans have picked on Saddam Hussein as the next target because they need a target; they don't feel they've really got to grips with whoever was responsible for September 11. That's rather frightening: what happens after Iraq? Maybe they'll find a European country they don't like.

I think September 11 struck a huge blow at America: not just physically, but at our idea of America. After the Second World War, America was a proud nation but not overbearing; in the past 10 years, it has seemed overmighty. September 11 showed that it has an Achilles heel. It made us look hard at the USA and ask if it was too powerful. There's a sense that America feels itself to be invincible, and when a country feels that, it's usually heading for a fall. The fact that Americans are so puzzled that they're disliked is itself a sign that something is at fault. They think the September 11 attack was spurred on by envy. I don't think people do envy the US; the al-Qa'ida hijackers were driven by hatred.

America has no fall-back position. It has to be confident and proud and feel invincible. Losing is not for Americans. I think people have started to rethink their attitudes to America, conscious that US culture is swamping the planet. There's a sense that America is locked into the 20th century and all it stood for, while in Europe we're moving on. I think, in a curious way, September 11 made Europeans more conscious and prouder that they are Europeans."

Richard Dawkins, scientist

"I felt a savage anger, and an instant bonding with America. For all its faults, the USA is a major centre of world civilisation, in some ways (admittedly not many) the greatest there has ever been. It was under attack from a pre-medieval barbarism, incapable of developing advanced technology but happy to parasitise the technology of the very society it enviously wanted to destroy with it.

My first thought was: "Religion strikes again." And so it proved (when Mohammed Atta's notebook was published). It's possible for political fanaticism alone to drive people to suicide attacks, but it's hard. Religion makes it easy because, to the deluded perpetrators, it isn't suicide at all. It's a wonder that human bombs, such as those that terrorise Israel, aren't more common. Perhaps they soon will be in America. And here, if Blair goes on playing poodle to Bush.

I was moved by the heroism of the New York firemen; by the faces of the bereaved; the agonising slow fall of tiny human forms; the inspirational, hands-on leadership of Mayor Giuliani – and the embarrassing contrast with President Bush, who spent the day zig-zagging aimlessly around the country in his private plane, like a squawking chicken. In the days that followed, my solidarity with America took a battering as the Bush tendency muscled in, the nauseating 'God bless America' became the unofficial national anthem.

I thought that the defeat of the odious Taliban was handled surprisingly well. But George Bush's identification of all trouble with a single abstract noun – 'terror' – is characteristically silly. The main way I have changed is in my attitude to religion. I used to think religion was harmless nonsense, entitled to at least some respect. I'd now drop the 'harmless'. And the last vestige of respect."

Tony Benn, activist and former Labour MP

"It was the most appalling tragedy for wholly innocent people. Its significance, now that we can see it against a historical perspective is, I think, very profound. Even a superpower on the scale of the United States is not invulnerable. It has, in a way, driven President Bush to adopt the same techniques as al-Qa'ida, ie, bomb innocent people to make a political point. One of the victims in the US has been civil liberties. The Charter of the UN has been torn up and now we are on the eve, we are told, of a war that would be illegal under the charter and in which far more innocent people would be killed than died on September 11.

The alternative between Johannesburg trying to save the world and Washington trying to destroy it is the thing that comes to my mind. That choice is becoming sharper. A year ago, anyone who was against the war was a usual suspect; now overwhelming opinion is against another Iraq war. Not just in Britain, but in America, very large numbers of people are opposed to it. September 11 has focused our minds on the choice we have to make. Do we go for revenge, or do we try to build a new world order that is durable and is based on justice and peace?"

AS Byatt, novelist

"It's changed the world because we've moved into a stage where hypothetical fears are now known to be realities. There always were articles on what would happen if terrorists attacked a big city. Now we know.Americans I know have reacted with dignified grief and a determination to get on as normal. I admire them. I feel much less sympathy with the public rhetoric of George Bush, which happens not to be the kind of rhetoric I like. I am a pacifist.

When Bush said: 'Whoever is not with us is against us,' Europeans suddenly felt they were European and not American. The word 'crusade' was a mistake. My feeling about that has intensified rather than lessened. What Tony Blair thinks is complicated, and this is the most interesting part of the puzzle for me.

The world has changed. If you stopped to think about risk, you knew intellectually that you were in danger; September 11 made us feel it. It made us feel we were in danger, as opposed to knowing."

Ian Jack: Writer and editor of 'Granta'

"I am not saying that the events of September 11 weren't terrible – of course they were. But so far they haven't substantially changed the way the Western world lives, unlike the two world wars of the last century. At the time, there was a lot of speculation about how our culture would change – how Hollywood films would become less violent, how tall buildings would go out of fashion. I can see no evidence of this.

The truth is that it is too early to say. A war with Iraq could change the world more seriously – but Iraq had nothing to do with September 11. What September 11 seems to have done is to supply the USA with an emotional lever for a war against a Muslim state. Another unpredictable consequence is that America is now less popular in the rest of the world than it was before 3,000 innocent people died there. You need a very poor political sense – step forward President Bush – to achieve that.

In the issue of Granta that was devoted to how writers felt about America, Harold Pinter wrote that it was 'a fully-fledged, award-winning, gold-plated monster'. Now that sentiment seems much less extreme, given Washington's selfish and ultimately self-damaging stance towards the rest of the world on a whole range of issues, from Palestine to global warming.

One last thing. Imagine this was September 1940, one year after the Second World War broke out. Were the newspapers filled with feverish anniversary-itis as every bit of the media is today? No – far more serious things were taking place. Doesn't that suggest that September 11 is a spectator event and that we have yet to feel its consequences? Let's hope we don't."

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The Commentators
What your genes reveal about you
Richard Dawkins

02/24/1997, The Independent - London, Page 15

Polly Toynbee is my hero, a journalistic knight in shining armour. To tone down the metaphor, she can usually be relied upon to hit any nail squarely on the head. But nobody is perfect, and even the best-placed and best-intentioned thumb occasionally sports a bruise. Her column last Thursday, "The nature of our DNA will always lag behind nurture", must not pass without correction, and I offer it in a spirit of pained admiration.

Owing to some weird tribal or union practice of the newspaper world, authors don't write their own headings, so Polly Toynbee cannot be blamed for: "Gene testing is pointless. Our fates are more likely to be shaped by our postcodes". Nevertheless, it is an accurate reflection of what she wrote.

But even if the postcode remark were true, gene testing wouldn't be pointless. Insurance actuaries would still want to read our genes, just as they record our smoking habits though the link between smoking and disease is statistical, not absolute. Both genes and smoking contribute to your risk. Nature and nurture are not competitors such that one wins and the other loses.

She gives the game away when she misuses the word "predictor": "Even those genes that show a strong disposition to specific conditions such as heart disease are not predictors. If those who know they are in danger eschew a diet of fried Mars bars they will not die of heart disease."

But we can simultaneously say, without contradiction: Even those environmental factors that show a strong disposition to specific conditions such as heart disease are not predictors. If you are fortunate in your genes you can eat fried Mars bars all day and you won't die of heart disease.

Both diet and genes contribute to the probability of heart disease. So do other factors such as stress. In the real world, prediction means statistical prediction, prediction of probability. When a tipster recommends a particular horse, he weighs up the past form of all the horses, adding in rumours and stable lad gossip together with expectations about the "going" (which in turn depend upon statistical weather forecasts). The result is a probability. On average you'll win more by following a good tipster than by betting completely at random.

When a successful racehorse is sold for stud, his purchaser is betting (lots of) money on a statistical prediction about the horse's genes. If there never had been genes for racing ability in horses, there wouldn't be a separate breed of racehorse at all. By analogy, there wouldn't be separate breeds of trotting horses, carthorses, polo ponies, sheepdogs, gundogs, or fighting bulls.

Is Homo sapiens some sort of bizarre exception to the rule? That doesn't sound a very Toynbeeish suggestion. She says "there is no gene for intelligence . . ." but she qualifies this by adding "there are a large number of genes responsible . . ." Yes indeed, but there are a large number of genes responsible for running speed in horses, milk yield in cows, pugnacity in fighting cocks and pit bull terriers. Why should the presence of many genes make prediction any less feasible?

Without getting into the notorious problems of defining intelligence, we can prove to ourselves that, in a powerfully predictive sense, there have been genes for intelligence for millions of years of human history. All you must assume is that, by whatever definition you are prepared to accept, we are more intelligent than our ape ancestors. Certainly our brains are spectacularly bigger than our fossil ancestors'. Right then, how has that evolutionary change come about?

There is only one way: genes for intelligence (or whatever you want to call the qualities that separate us from our ancestors) have been favoured in the gene pool. No evolutionary change in X can take place unless there are genes for X varying in the population. It follows that, during the millions of years in which we have been pulling ahead of our ape ancestors, some of us have been brighter than others, and it has been predictable from our genes. To deny that, you must deny Darwinism, something that a person of Polly Toynbee's education and intelligence will not do, however tempted by liberal good intentions.

Genes are important causal agents, combining with other genes and with environmental agents in the statistical determination of our abilities. The way in which they combine is best understood in terms of the statistical technique called "analysis of variance". Improvement in our understanding of the world is equivalent to an increase in our ability to predict outcomes as we take into account more causal agents. Equivalently, our uncertainty is progressively reduced, measured as increasing proportions of variance explained.

Variance is a measure of how variable a population is, and therefore how ignorant we are about any random member of it. The total variance is the sum of variance due to diet, due to education, due to genes, due to this, that or the other, plus finally a residue of unexplained variance. If all you know is that I am human, your best guess of my ability to run a mile is that I am average for the whole population. But your confidence is negligible. The population includes everything from aged cripples to babes in arms: the variance is large, and at this stage it all lies in the unexplained residue.

If I now tell you that I am male, in my twenties and in regular training, your confidence increases as portions of variance are shifted from unexplained residue to explained categories. If I now tell you that my father is called Roger Bannister, your estimate and your confidence change again. With each new piece of information, whether genetic or environmental, the unexplained variance decreases and the accuracy of the prediction increases.

There is a complication. Not all variance is "additive". Sometimes there are "interactions". In the statistical sense, this means something other than addition, and it is often treated as equivalent to multiplication. If a boy is very slightly cleverer than his brother for genetic reasons, the difference may be just enough to push him, but not his brother, through the eleven-plus and into grammar school. The eventual result of this may be that one brother becomes a professor, the other an unemployed labourer.

The difference in their genes is nowhere near enough to account for the final difference in worldly success. It has been multiplied by a threshold effect, the eleven-plus examination. The genes' contribution to the variance is no longer simply additive. There is a "genes x education" interaction. In the full analysis of variance, the total variance is partitioned into its additive components (genes, diet, education, etc) plus all the interactions (genes x education, genes x diet, education x diet, etc). Once again, there is a residue of unexplained variance, but we have reduced it by subtraction not only of the additive components but of the interactions too.

Interaction is a technical expression of what we see as "unfair" or "double jeopardy". Some people are disadvantaged by their genes and this will affect their lives and their health. That's bad enough. If insurance companies are allowed to use this information to penalise them again, they will end up penalised twice. Polly Toynbee is right - and typically so - to call for legal sanctions to make insurers spread the risk. Spreading risk is, after all, what insurance is all about. But we shan't help anybody, and might play into the hands of unscrupulous insurers, if we falsely underestimate the importance of genes.

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What’s Wrong with the Paranormal?

by Richard Dawkins

An almost unrecognizably hacked-about version of this appeared in the Sunday Mirror (London) on Sunday 8th Feb 1998, under the headline "Aliens are not among us."

Science tells us what we have reason to believe. Not what we have a duty to believe. Not what experts, in their pontificating wisdom, instruct us to believe. Not what some admired authority, like Albert Einstein or Stephen Hawking, believes. No, science tells us what there is good reason to believe.

History shows lots of examples where the best science of the day was wrong, superseded by later centuries. There’s much that science still doesn’t know. We’re quite happy to admit this. But it’s a challenge. We don’t just collapse with, "Oh well, it must be a miracle which we weren’t meant to understand." Instead, it’s, "OK, we don’t understand it yet. But we’re working on it."

Now, how about the paranormal? What does it mean? It’s been defined as ‘things that science cannot explain.’ That means ‘Cannot explain and never will’, which is much stronger than ‘Hasn’t yet solved’. Once it was mysterious how bats find their way in the dark. Now we know. They use echoes of squeaks too high for us to hear. Nobody wants to say that bats were once paranormal but aren’t any longer. And there’s nothing necessarily paranormal about faith-healing. Or visitors from outer space. I’ll bet there are creatures on other worlds. One day they may come here, though that is hugely less likely. And if they do come, it’s even less likely that they’ll look like us or want to abduct our women

To call something paranormal means that it is for ever impossible for science to explain. It’s a miracle. Like a perpetual motion machine, or a man pulling a train along by his teeth. Are there any authentic examples of such miracles? No. The philosopher David Hume pointed out that we should accept a miracle only if the alternative – hoax, lie, illusion or whatever – would be even more miraculously unlikely. Usually such alternatives are all too likely.

A recent poll showed nearly 50% believing in thought-reading. Actually, if telepathy ever were convincingly demonstrated, I’d treat as a fascinating problem that science doesn’t yet understand, like radio once would have been. But let’s talk about it anyway because, like astrology, if there were any evidence for it (there isn’t) it would be difficult for present day science to explain.

I can understand why so many people believe in telepathy. We’ve seen it ‘demonstrated’ on television. Or we’ve read about ‘uncanny’ experiences: say a mother suddenly has an overwhelming presentiment that her son in Australia is in danger – and later discovers that indeed he was. Let me explain why we ought not to be impressed by such ‘evidence’.

First the television ‘demonstrations’. These are just conjuring tricks. Not even very clever tricks. In one show compered by David Frost, a father and son team from Israel did the following act. The father appeared to ‘transmit’ numbers to his blindfolded son. When the time came for the ‘thought transference’, the father shouted out something, like "Can you do it son?" And the son croaked out the answer, "Five" or whatever it was. He was always correct. Since he was blindfolded, it had to be telepathy, right?

Wrong. There are any number of simple codes by which the father could have transmitted the number 5. The word count in his apparently innocent shout is one possibility. If the information to be transmitted had been 6 instead of 5, he might have shouted "Well, can you do it son?" If it had been 4, he could have shouted "Can you do it?" If 3, "Go ahead, son." Instead of gaping with amazement, David Frost should have tried the simple experiment of gagging the father as well as blindfolding the son.

It doesn’t matter exactly what trick this pair used. We’ve all seen better acts from conjurors at children’s parties. Then we’re told he’s only a conjuror, so we don’t ‘think paranormal.’ It’s only because David Frost is there, gasping and goggling, that we take it seriously.

I don’t know how conjurors do most of their tricks. I’m often astounded by them. I don’t understand how they pull rabbits out of hats or saw boxes in half without harming the lady inside. But I don’t believe it’s paranormal, and nor do you. We all know there’s a perfectly good explanation which the conjuror could tell us if he wanted to (understandably enough, he doesn't). So why should we think it a miracle when exactly the same kind of trick has the 'paranormal' label slapped on it by a television company?

If telepathy (or levitation, or lifting tables by the power of thought etc) were ever scientifically proved, its discoverer would deserve the Nobel Prize and probably get it. So why fool around doing party turns on television, instead? The reason is obvious. These performers are only doing tricks, and they know very well that they couldn't get away with it under scientifically controlled conditions.

Having said that, some 'paranormalists' are skilled enough to fool most scientists, and the people best qualified to see through them are other conjurors. This is why the most famous psychics and mediums regularly make excuses and refuse to go on stage if they hear that the front row of the audience is filled with professional conjurors.

Various good conjurors, including The Amazing Randi in America and Ian Rowland here, put on shows in which they publicly duplicate the 'miracles' of famous paranormalists – then explain to the audience that they are only tricks. The Rationalists of India are dedicated young conjurors who travel round the villages unmasking so-called 'holy men' by duplicating their 'miracles'. Unfortunately, some people still believe in miracles, even after the trickery has been explained. Others fall back on desperation: "Well maybe Randi does it by trickery", they say, "but that doesn't mean others aren't doing real miracles." To this, Ian Rowland memorably retorted: "Well, if they are doing miracles, they're doing it the hard way!"

Why, when he could earn a living as an honest conjuror, would someone pass himself off as a 'paranormal' miracle-worker. I'm sorry to say the answer's very simple. There's more money in it, and it's more glamorous. What jobbing conjuror could hope to break into television, with David Frost as fawning master of ceremonies? Or earn fat 'consultation fees' from oil companies for 'psychic divination' of where to drill? Or have Princess Diana drop onto your lawn by helicopter?

How about the uncanny experiences we read about? Say, dreaming of a long-forgotten uncle, then waking to be told that he died in the night. There's no trickery here. The people who have these experiences are sincere, and who can blame them? It can be very weird. It's just that most of us are bad at probability theory. An American scientist who had a spookily prophetic dream sat down next day and did some sums. He estimated the odds that, by chance alone, an experience as uncanny as his would happen to a person in any one night. It came to a low probability, as you'd expect. But, given the population of the United States, he worked out that approximately 300 people would be experiencing coincidences at least as weird as his, every day. Only those who have those experiences bother to remember them, or write to the newspapers. That's why we hear about them. Nobody writes to the paper and says: "I dreamed that my uncle had died. And when I woke next morning, would you believe it, there was nothing wrong with him."

How about performers who seem to 'sense' that somebody in the audience had a loved one whose name began with M, owned a Pekinese, and died of something to do with the chest – 'clairvoyants' and 'mediums' with 'inside knowledge' that they 'couldn't have got by any normal means'? I haven't space to go into details, but the trick is well known to conjurors under the name 'cold reading'. It's a subtle combination of knowing what's common (many people die of heart failure or lung cancer), and fishing for clues (people give the game away when you are getting warm), aided by the audience's willingness to remember hits and overlook misses. Cold readers also often use narks, who eavesdrop conversations as the audience walks into the theatre.

When done well, cold reading can be impressive, but it's perfectly well understood and there's nothing miraculous about it. There are excellent books which explain cold reading and lots of other 'paranormal' tricks, including Bizarre Beliefs by Mike Hutchinson and Simon Hoggart (Prometheus Books) and Why People Believe Weird Things by Michael Shermer (W.H.Freeman). To see the lid taken off astrology, water divining, faith healing, levitation and much else, read Flim-Flam by James Randi (Prometheus Books). For beautifully-written reflections on the richness of science and the poverty of the paranormal, everyone should read Carl Sagan's The Demon Haunted World (Hodder Headline). Oh, and in case you've ever been impressed by spoonbending, the American conjurors Penn and Teller explain on the Internet exactly how that's done: http://www.randi.org/jr/ptspoon.html.(link does not seem to be there anymore - John C)

The paranormal is bunk. Those who try to sell it to us are fakes and charlatans, and some of them have grown rich and fat by taking us for a ride. You wouldn't fall for a smooth salesman who offered you a car without an engine. So why be fooled by paranormal con-artists? What they are selling you doesn’t work. Send them packing and drive them out of business.

Home
John Catalano

When Religion Steps on Science's Turf & The Emptiness of Theology

When Religion Steps on Science's Turf
The Alleged Separation Between the Two Is Not So Tidy
by Richard Dawkins
Published in Free Inquiry magazine, Volume 18, Number 2.

A cowardly flabbiness of the intellect afflicts otherwise rational people confronted with long-established religions (though, significantly, not in the face of younger traditions such as Scientology or the Moonies). S. J. Gould, commenting in his Natural History column on the pope's attitude to evolution, is representative of a dominant strain of conciliatory thought, among believers and nonbelievers alike: "Science and religion are not in conflict, for their teachings occupy distinctly different domains ... I believe, with all my heart, in a respectful, even loving concordat [my emphasis] ...."

Well, what are these two distinctly different domains, these "Nonoverlapping Magisteria" that should snuggle up together in a respectful and loving concordat? Gould again: "The net of science covers the empirical universe: what is it made of (fact) and why does it work this way (theory). The net of religion extends over questions of moral meaning and value."

Who Owns Morals?

Would that it were that tidy. In a moment I'll look at what the pope actually says about evolution, and then at other claims of his church, to see if they really are so neatly distinct from the domain of science. First though, a brief aside on the claim that religion has some special expertise to offer us on moral questions. This is often blithely accepted even by the nonreligious, presumably in the course of a civilized "bending over backwards" to concede the best point your opponent has to offer - however weak that best point may be.

The question, "What is right and what is wrong?" is a genuinely difficult question that science certainly cannot answer. Given a moral premise or a priori moral belief, the important and rigorous discipline of secular moral philosophy can pursue scientific or logical modes of reasoning to point up hidden implications of such beliefs, and hidden inconsistencies between them. But the absolute moral premises themselves must come from elsewhere, presumably from unargued conviction. Or, it might be hoped, from religion - meaning some combination of authority, revelation, tradition, and scripture.

Unfortunately, the hope that religion might provide a bedrock, from which our otherwise sand-based morals can be derived, is a forlorn one. In practice, no civilized person uses Scripture as ultimate authority for moral reasoning. Instead, we pick and choose the nice bits of Scripture (like the Sermon on the Mount) and blithely ignore the nasty bits (like the obligation to stone adulteresses, execute apostates, and punish the grandchildren of offenders). The God of the Old Testament himself, with his pitilessly vengeful jealousy, his racism, sexism, and terrifying bloodlust, will not be adopted as a literal role model by anybody you or I would wish to know. Yes, of course it is unfair to judge the customs of an earlier era by the enlightened standards of our own. But that is precisely my point! Evidently, we have some alternative source of ultimate moral conviction that overrides Scripture when it suits us.

That alternative source seems to be some kind of liberal consensus of decency and natural justice that changes over historical time, frequently under the influence of secular reformists. Admittedly, that doesn't sound like bedrock. But in practice we, including the religious among us, give it higher priority than Scripture. In practice we more or less ignore Scripture, quoting it when it supports our liberal consensus, quietly forgetting it when it doesn't. And wherever that liberal consensus comes from, it is available to all of us, whether we are religious or not.

Similarly, great religious teachers like Jesus or Gautama Buddha may inspire us, by their good example, to adopt their personal moral convictions. But again we pick and choose among religious leaders, avoiding the bad examples of Jim Jones or Charles Manson, and we may choose good secular role models such as Jawaharlal Nehru or Nelson Mandela. Traditions too, however anciently followed, may be good or bad, and we use our secular judgment of decency and natural justice to decide which ones to follow, which to give up.

Religion on Science's Turf

But that discussion of moral values was a digression. I now turn to my main topic of evolution and whether the pope lives up to the ideal of keeping off the scientific grass. His "Message on Evolution to the Pontifical Academy of Sciences" begins with some casuistical doubletalk designed to reconcile what John Paul II is about to say with the previous, more equivocal pronouncements of Pius XII, whose acceptance of evolution was comparatively grudging and reluctant. Then the pope comes to the harder task of reconciling scientific evidence with "revelation."

Revelation teaches us that [man] was created in the image and likeness of God. ... if the human body takes its origin from pre-existent living matter, the spiritual soul is immediately created by God ... Consequently, theories of evolution which, in accordance with the philosophies inspiring them, consider the mind as emerging from the forces of living matter, or as a mere epiphenomenon of this matter, are incompatible with the truth about man. ... With man, then, we find ourselves in the presence of an ontological difference, an ontological leap, one could say.

To do the pope credit, at this point he recognizes the essential contradiction between the two positions he is attempting to reconcile: "However, does not the posing of such ontological discontinuity run counter to that physical continuity which seems to be the main thread of research into evolution in the field of physics and chemistry?"

Never fear. As so often in the past, obscurantism comes to the rescue:

Consideration of the method used in the various branches of knowledge makes it possible to reconcile two points of view which would seen irreconcilable. The sciences of observation describe and measure the multiple manifestations of life with increasing precision and correlate them with the time line. The moment of transition to the spiritual cannot be the object of this kind of observation, which nevertheless can discover at the experimental level a series of very valuable signs indicating what is specific to the human being.

In plain language, there came a moment in the evolution of hominids when God intervened and injected a human soul into a previously animal lineage. (When? A million years ago? Two million years ago? Between Homo erectus and Homo sapiens? Between "archaic" Homo sapiens and H. sapiens sapiens?) The sudden injection is necessary, of course, otherwise there would be no distinction upon which to base Catholic morality, which is speciesist to the core. You can kill adult animals for meat, but abortion and euthanasia are murder because human life is involved.

Catholicism's "net" is not limited to moral considerations, if only because Catholic morals have scientific implications. Catholic morality demands the presence of a great gulf between Homo sapiens and the rest of the animal kingdom. Such a gulf is fundamentally anti-evolutionary. The sudden injection of an immortal soul in the timeline is an anti-evolutionary intrusion into the domain of science.

More generally it is completely unrealistic to claim, as Gould and many others do, that religion keeps itself away from science's turf, restricting itself to morals and values. A universe with a supernatural presence would be a fundamentally and qualitatively different kind of universe from one without. The difference is, inescapably, a scientific difference. Religions make existence claims, and this means scientific claims.

The same is true of many of the major doctrines of the Roman Catholic Church. The Virgin Birth, the bodily Assumption of the Blessed Virgin Mary, the Resurrection of Jesus, the survival of our own souls after death: these are all claims of a clearly scientific nature. Either Jesus had a corporeal father or he didn't. This is not a question of "values" or "morals"; it is a question of sober fact. We may not have the evidence to answer it, but it is a scientific question, nevertheless. You may be sure that, if any evidence supporting the claim were discovered, the Vatican would not be reticent in promoting it.

Either Mary's body decayed when she died, or it was physically removed from this planet to Heaven. The official Roman Catholic doctrine of Assumption, promulgated as recently as 1950, implies that Heaven has a physical location and exists in the domain of physical reality - how else could the physical body of a woman go there? I am not, here, saying that the doctrine of the Assumption of the Virgin is necessarily false (although of course I think it is). I am simply rebutting the claim that it is outside the domain of science. On the contrary, the Assumption of the Virgin is transparently a scientific theory. So is the theory that our souls survive bodily death, and so are all stories of angelic visitations, Marian manifestations, and miracles of all types.

There is something dishonestly self-serving in the tactic of claiming that all religious beliefs are outside the domain of science. On the one hand, miracle stories and the promise of life after death are used to impress simple people, win converts, and swell congregations. It is precisely their scientific power that gives these stories their popular appeal. But at the same time it is considered below the belt to subject the same stories to the ordinary rigors of scientific criticism: these are religious matters and therefore outside the domain of science. But you cannot have it both ways. At least, religious theorists and apologists should not be allowed to get away with having it both ways. Unfortunately all too many of us, including nonreligious people, are unaccountably ready to let them.

I suppose it is gratifying to have the pope as an ally in the struggle against fundamentalist creationism. It is certainly amusing to see the rug pulled out from under the feet of Catholic creationists such as Michael Behe. Even so, given a choice between honest-to-goodness fundamentalism on the one hand, and the obscurantist, disingenuous doublethink of the Roman Catholic Church on the other, I know which I prefer.

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The Emptiness of Theology

by Richard Dawkins

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A dismally unctuous editorial in the British newspaper the Independent recently asked for a reconciliation between science and "theology." It remarked that "People want to know as much as possible about their origins." I certainly hope they do, but what on earth makes one think that theology has anything useful to say on the subject?

Science is responsible for the following knowledge about our origins. We know approximately when the universe began and why it is largely hydrogen. We know why stars form and what happens in their interiors to convert hydrogen to the other elements and hence give birth to chemistry in a world of physics. We know the fundamental principles of how a world of chemistry can become biology through the arising of self-replicating molecules. We know how the principle of self-replication gives rise, through Darwinian selection, to all life, including humans.

It is science and science alone that has given us this knowledge and given it, moreover., in fascinating, over-whelming, mutually confirming detail. On every one of these questions theology has held a view that has been conclusively proved wrong. Science has eradicated smallpox, can immunize against most previously deadly viruses, can kill most previously deadly bacteria. Theology has done nothing but talk of pestilence as the wages of sin. Science can predict when a particular comet will reappear and, to the second, when the next eclipse will appear. Science has put men on the moon and hurtled reconnaissance rockets around Saturn and Jupiter. Science can tell you the age of a particular fossil and that the Turin Shroud is a medieval fake. Science knows the precise DNA instructions of several viruses and will, in the lifetime of many present readers, do the same for the human genome.

What has theology ever said that is of the smallest use to anybody? When has theology ever said anything that is demonstrably true and is not obvious? I have listened to theologians, read them, debated against them. I have never heard any of them ever say anything of the smallest use, anything that was not either platitudinously obvious or downright false. If all the achievements of scientists were wiped out tomorrow, there would be no doctors but witch doctors, no transport faster than horses, no computers, no printed books, no agriculture beyond subsistence peasant farming. If all the achievements of theologians were wiped out tomorrow, would anyone notice the smallest difference? Even the bad achievements of scientists, the bombs, and sonar-guided whaling vessels work! The achievements of theologians don't do anything, don't affect anything, don't mean anything. What makes anyone think that "theology" is a subject at all?

Where do the real dangers of genetic engineering lie?

by Richard Dawkins

Published in The London Evening Standard Aug 19 1998

Scare stories about genetic engineering may divert our attention from areas where we do need to be on our guard against cynical exploiters

To listen to some people, you'd think genetically modified foods were radioactive. But genetic engineering is not, of itself, either bad or good. It depends what you engineer. Doubtless a malevolent geneticist could stick a poison gene into a potato. If we insert a gene for making oil of peppermint, we'll end up with peppermint flavoured potatoes. It's up to us.

There's nothing new about genetic modification. That's precisely what Darwinian evolution is and it's Darwinian evolution that put us all here. All plants and animals including humans, are genetically modified versions of ancestors. Darwinian modifications are not designed; they evolve by natural selection - the survival of the fittest - which may or may not be good from our point of view. Mosquitoes are genetically modified by natural selection to eat humans, which is good for them and bad for us. Silkworms are genetically modified by natural selection to make silk, which is good for them and also good for us because we steal the stuff.

Most genes are placed where they are by natural evolution. We can achieve a little further adjustment by artifice, and here we at least have the opportunity to tailor changes that are good for us. We can selectively breed - a kind of artificial version of Darwinian selection which we've been practising for thousands of years. And we can genetically engineer. This is a technique that we're only just beginning to learn, and like all novelty it arouses fear.

Genetically engineered plants have been sensation-ally called Frankenstein plants. But traditionally-bred domestic peas are 10 times the volume of their wild ancestors. Does this make them Frankenstein peas? The wild ancestors of corn cobs were half an inch long. Today a domestic cob may be one and a half feet long. Yet nobody accuses our forebears of "playing God" when they bred them. Are spaniels and whippets Frankenstein wolves?

PR E S U M A B L Y selective breeding seems less sinister because it is a little older than genetic engineering. But both techniques are extremely young compared with the long history of Darwinian genetic modification that produced wild plants and animals in the first place. I am reminded of the old lady who refused to enter an aeroplane, on the grounds that if God had meant us to fly He'd never have given us the railway.

Both natural selection (which gave us the maize plant in the first place) and artificial selection (which lengthened its cobs thirty-fold) depend upon random genetic error - mutation - and recombination, followed by non-random survival. The difference is that in natural selection the fittest automatically survive. In artificial selection we choose the survivors, and we may also arrange cunning hybridization regimes. In genetic engineering we additionally exercise control over the mutations themselves. We do this either by directly doctoring the genes, or by importing them from another species, sometimes a very distant species. This is what "transgenic" means.

And now, here's a potential problem. Natural selection favours genes that have had plenty of time to get adjusted to the other genes that are also being favoured in the species - the gene pool becomes a balanced set of mutually compatible genes (I explain this in a chapter called The Selfish Cooperator in my forthcoming book, Unweaving the Rainbow). One of the problems with artificial selection (partly because domestication is so recent) is that the balance may be upset. Pekineses, bred to satisfy questionable human whims, have consequent difficulties with their breathing. Bulldogs have trouble being born. Transgenic importation of genes might raise even worse problems of this kind, because the genes come from a more distantly alien genetic climate, and the translocation is even more recent. This is a danger we must think about.

Genetic engineering is a more powerful way to modify life than traditional artificial selection, so the potential for danger is greater as well as the potential for good. Environmental dangers are likely to outweigh nutritional ones, mainly because knock-on environmental effects are so complicated and hard to predict. But some risks can be foreseen. Suppose there is an indiscriminate poison which is cheaper to produce than sophisticated selective weedkillers, but which cannot be used because it kills the crop along with the weeds. Now suppose a gene is introduced which makes wheat, say, completely immune to this particular herbicide.

FARMERS who sow the transgenic wheat can scatter the otherwise deadly poison with impunity, thereby increasing their profits but with potentially disastrous effects on the environment. If the same company patents both the poison and its genetic antidote, the monopolistic combination would be a nice little earner for the company, while the rest of us would see it as a menace. On the other hand, enlightened genetic engineers might achieve an exactly opposite effect, positively benefiting the environment by reducing the quantity of weedkiller required. There is a choice.

Part of what we have to fear from genetic engineering is a paradox - it is too good at what it does. As ever, science's formidable power makes correspond-ingly formidable demands on society's wisdom. The more powerful the science, the greater the potential for evil as well as good. And the more important it is that we make the right choices over how we use it. A major difficulty is political - deciding who is the "we" in that sentence. If decisions over genetic engineering are left to the marketplace alone, the long-term interests of the environment are unlikely to be well served. But that is true about so many aspects of life.

Hysterical damners of genetic engineering in all its forms are tactically inept, like the boy who cried wolf. They distract attention from the real dangers that might follow from abusing the technology, and they therefore play into the hands of cynical corporations eager to profit from such abuse.

Where d'you get those peepers

Dawkins, Richard, Where d'you get those peepers?., Vol. 8, New Statesman & Society, 06-16-1995, pp 29.

Creationist claims that organs like eyes are too complex to have evolved naturally are way wide of the mark, says Richard Dawkins. In fact, eyes have evolved many times, often in little more than a blink of geological history

Creationism has enduring appeal, and the reason is not far to seek. It is not, at least for most of the people I encounter, because of a commitment to the literal truth of Genesis or some other tribal origin story. Rather, it is that people discover for themselves the beauty and complexity of the living world and conclude that it "obviously" must have been designed. Those creationists who recognise that Darwinian evolution provides at least some sort of alternative to their scriptural theory often resort to a slightly more sophisticated objection. They deny the possibility of evolutionary intermediates. "X must have been designed by a Creator," people say, "because half an X would not work at all. All the parts of X must have been put together simultaneously; they could not have evolved gradually."

Thus the creationist's favourite question "What is the use of half an eye?" Actually, this is a lightweight question, a doddle to answer. Half an eye is just 1 per cent better than 49 per cent of an eye, which is already better than 48 per cent, and the difference is significant. A more ponderous show of weight seems to lie behind the inevitable supplementary: "Speaking as a physicist, I cannot believe that there has been enough time for an organ as complicated as the eye to have evolved from nothing. Do you really think there has been enough time?" Both questions stem from the Argument from Personal Incredulity. Audiences nevertheless appreciate an answer, and I have usually fallen back on the sheer magnitude of geological time.

It now appears that the shattering enormity of geological time is a steam hammer to crack a peanut. A recent study by a pair of Swedish scientists, Dan Nilson and Susanne Pelger, suggests that a ludicrously small fraction of that time would have been plenty. When one says "the" eye, by the way, one implicitly means the vertebrate eye, but serviceable image-forming eyes have evolved between 40 and 60 times, independently from scratch, in many different invertebrate groups. Among these 40-plus independent evolutions, at least nine distinct design principles have been discovered, including pinhole eyes, two kinds of camera-lens eyes, curved-reflector ("satellite dish") eyes, and several kinds of compound eyes. Nilsson and Pelger have concentrated on camera eyes with lenses, such as are well developed in vertebrates and octopuses.

How do you set about estimating the time required for a given amount of evolutionary change? We have to find a unit to measure the size of each evolutionary step, and it is sensible to express it as a percentage change in what is already there. Nilsson and Pelger used the number of successive changes of x per cent as their unit for measuring changes of anatomical quantities.

Their task was to set up computer models of evolving eyes to answer two questions. The first was: is there a smooth gradient of change, from flat skin to full camera eye, such that every intermediate is an improvement? (Unlike human designers, natural selection can't go downhill not even if there is a tempting higher hill on the other side of the valley.) Second, how long would the necessary quantity of evolutionary change take?

In their computer models, Nilsson and Pelger made no attempt to simulate the internal workings of cells. They started their story after the invention of a single light-sensitive cell--it does no harm to call it a photocell. It would be nice, in the future, to do another computer model, this time at the level of the inside of the cell. to show how the first living photocell came into being by step-by-step modification of an earlier, more general-purpose cell. But you have to start somewhere, and Nilsson and Pelger started after the invention of the photocell.

They worked at the level of tissues: the level of stuff made of cells rather than the level of individual cells. Skin is a tissue, so is the lining of the intestine, so is muscle and liver. Tissues can change in various ways under the influence of random mutation. Sheets of tissue can become larger or smaller in area. They can become thicker or thinner. In the special case of transparent tissues like lens tissue, they can change the refractive index (the light-bending power) of local parts of the tissue.

The beauty of simulating an eye, as distinct from, say, the leg of a running cheetah, is that its efficiency can be easily mea-optics. The eye is represented as a two-dimensional cross-section, and the computer can easily calculate its visual acuity, or spatial resolution, as a single real number. It would be much harder to come up with an equivalent numerical expression for the efficacy of a cheetah's leg or backbone. Nilsson and Pelger began with a flat retina atop a flat pigment layer and surmounted by a flat, protective transparent layer. The transparent layer was allowed to undergo localised random mutations of its refractive index. They then let the model deform itself at random, constrained only by the requirement that any change must be small and must be an improvement on what went before.

The results were swift and decisive. A trajectory of steadily mounting acuity led unhesitatingly from the flat beginning through a shallow indentation to a steadily deepening cup, as the shape of the model eye deformed itself on the computer screen. The transparent layer thickened to fill the cup and smoothly bulged its outer surface in a curve. And then, almost like a conjuring trick, a portion of this transparent filling condensed into a local, spherical subregion of higher refractive index. Not uniformly higher, but a gradient of refractive index such that the spherical region functioned as an excellent graded- index lens.

Graded-index lenses are unfamiliar to human lens-makers, but they are common in living eyes. Humans make lenses by grinding glass to a particular shape. We make a compound lens. like the expensive violet-tinted lenses of modern cameras. by mounting several lenses together, but each one of those individual lenses is made of uniform glass through its whole thickness. A graded-index lens, by contrast, has a continuously varying refractive index with in its own substance. Typically, it has a high refractive index near the centre of the lens. Fish eyes have graded-index lenses. Now it has long been known that, for a graded-index lens, the most aberration-free results are obtained when you achieve a particular theoretical optimum value for the ratio between the focal length of the lens and the radius. This ratio is called Mattiessen's ratio. Nilsson and Pelger's computer model homed in unerringly on Mattiessen's ratio.

And so to the question of how long all this evolutionary change might have taken. In order to answer this, Nilsson and Pelger had to make some assumptions about genetics in natural populations. They needed to feed their model plausible values of quantities such as "heritability" . Heritability is a measure of how far variation is governed by heredity. The favoured way of measuring it is to see how much monozygotic (that is, "identical") twins resemble each other compared with ordinary twins. One study found the heritability of leg length in male humans to be 77 per cent. A heritability of too per cent would mean that you could measure one identical twin's leg to obtain perfect knowledge of the other twin's leg length, even if the twins were reared apart. A heritability of 0 per cent would mean that the legs of monozygotic twins are no more similar to each other than to the legs of random members of a specified population in a given environment. Some other heritabilities measured for humans are 95 per cent for head breadth, 85 per cent for sitting height. 80 percent for arm length and 79 per cent for stature.

Heritabilities are frequently more than 50 percent, and Nilsson and Pelger therefore felt safe in plugging a heritability of 50 per cent into their eye model. This was a conservative, or "pessimistic", assumption. Compared with a more realistic assumption of, say, 70 per cent, a pessimistic assumption tends to increase their final estimate of the time taken for the eye to evolve. They wanted to err on the side of overestimation because we are intuitively skeptical of short estimates of the time taken to evolve something as complicated as an eye.

For the same reason, they chose pessimistic values for the coefficient of variation (that is, for how much variation there typically is in the population) and the intensity of selection (the amount of survival advantage improved eyesight confers). They even went so far as to assume that any new generation differed in only one part of the eye at a time: simultaneous changes in different parts of the eye, which would have greatly speeded up evolution, were outlawed. But even with these conservative assumptions, the time taken to evolve a fish eye from fiat skin was minuscule: fewer than 400,000 generations. For the kinds of small animals we are talking about, we can assume one generation per year, so it seems that it would take less than half a million years to evolve a good camera eye.

In the light of Nilsson and Pelger's results, it is no wonder "the" eye has evolved at least 40 times independently around the animal kingdom. There has been enough time for it to evolve from scratch 1,500 times in succession within any one lineage. Assuming typical generation lengths for small animals, the time needed for the evolution of the eye, far from stretching credulity with its vastness, turns out to be too short for geologists to measure! It is a geological blink.

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Whole Earth Review, Spring 1989 n62 p90(10)

Universal parasitism and the co-evolution of extended phenotypes. (genetic influences reach outside the body) Richard Dawkins.

To understand Dawkins' thesis you'll need to keep the following distinctions

in mind: Phenotype is the observable appearance of an organism, while genotype is the hidden governing constitution. The genotype manifests itself through the physical attributes of the phenotype. An organism that is of a particular genotype is called a genome.

IN MANY RELIGIOUS CULTS AROUND THE world, ancestors are worshipped. And well they may be, for ancestors, not gods, hold the key to understanding why living things are the way that they are. Of all organisms born, the majority die before they come of age. Of the minority that become parents, an even smaller minority will have descendants alive 1,000 years hence. A tiny minority are the only ones that future generations will be able to call ancestors. This minority had what it takes to be successful. Every organism alive can look back at its ancestors and say the following: Not a single one of my ancestors was killed by a predator, or by a virus, or by a misjudged footstep on a precipice, or a mis-timed handhold on a high tree branch, before begetting or bearing at least one child. Not a single one of my ancestors was too unattractive to find at least one copulation partner, or too selfish a parent to nurture at least one child through to adulthood. Thousands of my ancestors' contemporaries failed in all these respects, but not a single, solitary one of my ancestors failed.

Since all organisms alive inherit their genes from their ancestors, rather than from their ancestors' unsuccessful contemporaries, all organisms alive tend to possess successful genes. This is why organisms tend to inherit genes that build a well-designed machine, a machine that behaves as if it is striving to become an ancestor.

The rationale for this view of life can be seen only if we focus attention on the genes themselves (Williams, 1966; Dawkins, 1976). Genes are documentary information handed down, in the form of copies, from generation to generation. But genes are not only archival documents, passed like a family Bible from ancestor to descendant. They also exert a causal influence on each of the bodies in which they successively reside. They influence the development of arms and legs, of eyes and skins, brains and behavior patterns. Those genes that just happen to cause successive bodies to be more likely to die young, or to be unattractive to the opposite sex, or to fail in caring for children, are not the genes that pass through the net of natural selection into future generations of bodies. It follows that the animals that we see tend to be built by good genes: genes that are good at making bodies that, in turn, are good at passing those same genes on to future generations. It further follows that we can regard an individual animal as a machine for passing on the genes that it contains, a "survival machine" as I have put it.

The way that behavioral ecologists normally express this is to say that individual animals behave in such a way as to maximize their reproductive success. More precisely, it is referred to as their inclusive fitness (Hamilton, 1964). This doctrine has become orthodoxy. When a modern behavioral ecologist sees an animal doing behavior pattern A in situation P, his immediate reaction is to ask: "In what way is behavior pattern A good for the animal in situation P?" His colleagues may disagree with the answer he comes up with. Some of them may dispute the premise of the question, accusing him of being too "adaptationist, " perhaps of neglecting a "developmental constraint, or of neglecting the power of neutral drift. But, following my book The Extended Phenotype (1982), I want to raise a very different kind of problem. I suspect that the animal we are watching may be being manipulated by some other animal or plant, perhaps behind the scenes.

The animal we are watching is moving under the power of its own muscles, of course, and its own brain is giving the orders. Since the brain and muscles grew under the influence of the animal's own genes we assume, as good neo-Darwinians, that the brain and muscles are working for the benefit of the animal's own genes. But what if there is some other animal lurking behind the scenes, pulling the puppet strings? Then, instead of asking "In what way is this animal benefiting from its behavior?" we should ask: "Which animal is this behavior benefiting?"

Parasites provide most of the examples we know about so far. Many flukes have a complicated life cycle, involving one or more intermediate hosts, before they finally infect their definitive host. For instance, flukes of the genus Leucochloridium have a snail as their intermediate host. From this they have to pass to a bird, and, in order for this to happen, their snail must be eaten by a bird, or at least the part of the snail containing the fluke. They could just sit back and wait for this to happen, but in fact they take active steps to make it happen. They burrow up into the tentacles of the snail, where they can be seen through the snail's skin, conspicuously pulsating. This makes the tentacles look to a bird like tempting morsels in their own right. Wickler (1985) suggests that they look like insects. Anyway, birds peck them off, and the fluke achieves the next stage in its life cycle.

What is more interesting from our point of view is that the flukes even manage to change the snails' behavior. The snails are normally negatively phototactic: they tend to avoid light, and therefore do not approach the tops of plants on which they feed. Infected snails change their behavior. They become positively phototactic, actively seeking light. This carries them up to the open tops of the plants, and makes them more likely to be seen by birds. Perhaps the fluke achieves this by interfering with the optic nerves of the snail: the eyes are, after all, in the tips of the tentacles into which the flukes have burrowed. From our point of view, it is sufficient that the parasites do change the behavior of the host, in such a way as to benefit the parasite, but not the host. If a behavioral ecologist watched the behavior of the snail, and asked: "In what way does its light-seeking behavior benefit the snail?" he would seek in vain for an answer. The truth is that some other animal, in this case a fluke, is manipulating the snail from behind the scenes. The behavioral ecologist would have done better to ask: "Which animal is this behavior benefiting?"

It is not just behavior that parasites manipulate. There is a protozoan parasite, Nosema, that infects beetle larvae. As far as the beetle larva is concerned, the purpose of its existence is to feed and grow until it is big enough to metamorphose into an adult beetle and reproduce. But the parasite has no interest in its host's reproducing. The parasite simply "wants" its host to go on growing and providing food for more and more of the parasite's descendants. It achieves this by a remarkable feat of biochemical manipulation. The parasites together (presumably they are a clone) succeed in synthesizing the juvenile hormone, or a close chemical analog of it. juvenile hormone is the substance that insects normally synthesize to maintain larval growth and inhibit metamorphosis. Human experimenters have shown that, if you inject an insect larva with juvenile hormone, you can stop it metamorphosing. These Nosema parasites have "discovered" the same thing! They synthesize the juvenile hormone and secrete it into the beetle larva's body. Instead of metamorphosing, the larva continues to grow through as many as six extra larval moults, end- ing up as a giant larva more than twice the normal size.

In the case of the snail's phototaxis, it might have been possible to regard the change as an accidental byproduct, not as a true adaptation by the parasite. In the case of Nosema, it is hardly possible to maintain this. juvenile hormone is not something that protozoa ordinarily have anything to do with. Achieving the feat of synthesizing a specific molecule like a hormone indicates true adaptation by natural selection over many generations.

Once again, the conclusion I want to draw concerns the kind of question that behavioral ecologists should ask. We are tempted to look at a giant beetle larva and ask: "How does this giantism benefit the insect?" Instead, we should ask: "Who is benefiting from the giantism?" The answer, once again, is not the animal itself, but a manipulator hidden behind the scenes.

These examples are all from the point of view of individual organisms. But, as stated at the outset, all adaptation should fundamentally be seen at the genetic level. If the animal we are watching is behaving for the benefit of a manipulator behind the scenes, we must express this at the genetic level. Just as, in normal adaptation, we say that an animal behaves so as to benefit the genes that it contains, so, in the case of these parasites, we must say that the host behaves in such a way as to benefit the parasite's genes. And the reason is the same. just as, normally, an animal's development is influenced by the genes that it contains, so a parasitized beetle larva's development is influenced by the genes of the parasite. The conclusion of the doctrine of the extended phenotype" is that a gene in one animal may have phenotypic expression in the body of another animal. It is this doctrine that I want to persuade you of, and I am doing so largely by talking about parasites.

The snail can be regarded as a vehicle exploited by a fluke. A beetle larva can be regarded as a vehicle exploited by a protozoan parasite. But the selfish gene view of life sees this as just a larger version of the normal relationship of a gene to the body in which it sits. A body is just a gene's vehicle for getting into the next generation, and hence into an indefinite series of future generations. A snail is just a fluke's way of getting into a sheep, and hence of getting its genes into the future.

But why do we assume that the fluke genes work with a kind of group loyalty to one another, while the snail genes oppose them and work with a group loyalty to one another? Many people do not see this as a question that needs an answer at all. They see it as the starting assumption, that the whole of a body works together for the entire reproductive success of all of that body, in other words, for the propagation of all its genes.

But it is more fundamental for genes to work in their own interests. Under what circumstances might we expect genes within one genome to rebel, and not to pull together with one another for the common good? We would expect this if some genes had found a way of breaking out of the ordinary meiotic lottery involved in making gametes [the random division of chromosomes], and succeeded in manipulating their bodies into spreading them some other way. Suppose, for instance, that a gene succeeded in making its bodies sneeze them out, so that they could be breathed in by another body. Such a gene might well share with ordinary genes the same interest in preserving the individual body alive. But it would not share with ordinary genes the same interest in making that body have offspring, via sperm or eggs. This partial divergence of interests will tend to make the sneezed genes behave in a more detrimental, parasitic" manner. Are there any examples of such genes? Well, if there were, by definition we would not call them members of the body's own genome. We might call them virus genes.

The only reason all genes are not rebels like this is that all the genes in one individual organism normally stand to gain from the propagation of the gametes of that organism. Rebelling is difficult, for reasons that in themselves require an explanation, and which have to do with the disciplined fairness of the meiotic lottery. Given that rebelling is difficult because of the way meiosis works, selfish genes can normally actually benefit themselves best by cooperating with others in the same body, in order to promote the reproduction of that body, as a coherent entity.

Briefly, I believe that this amicable state of affairs comes about in the following general way. Genes that can make use of one another's products tend to prosper in one another's presence. This sets up a climate in which genes that cooperate are favored. "Climate" means a climate provided by other genes. From any one gene's point of view, other genes can be regarded as part of the environment, in much the same way as the external temperature and humidity can be regarded as part of the environment. "Cooperate" just means work together, especially work together to make the whole genome behave as a single coherently purposeful unit. This in turn increases the unitariness and coherence of the body, which in turn increases the pressure for the genes to be even more cooperative, and specifically increases the pressure for all the genes to converge upon the same method of leaving the body. So we have a self-sustaining, self-reinforcing evolutionary trend towards large units of phenotypic power. To go back to the example of snails and flukes, we normally think of parasites as weakening their hosts. But there are some cases where, at least at first sight, they strengthen their hosts. Cases have been reported of snails parasitized by flukes having thicker and stronger shells than unparasitized snails. Does this mean that the snails actually derive some benefit from the flukes? In the sense of being better protected, the answer may well be yes, but it will not be a net benefit. When we consider benefits, we must not forget economic costs. It costs calcium and perhaps other resources to make a thick shell. We may be sure that the snail, and not the fluke, is bearing these costs. From the snail's point of view, a shell that is too thin is bad, for the obvious reason that it provides inadequate protection. But a shell that is too thick is also bad, because it consumes resources that could have been spent more profitably elsewhere in the economy of the snail. for instance, in making more eggs. Admittedly a super-thick shell presumably provides even better protection than a normal shell, but if, so to speak, the snails thought it worthwhile for this reason, they would have invested in it anyway! By making them have a thicker shell than they "want, " the flukes are not doing the snails a favor, unless the flukes are, in some way, shouldering the economic cost of the extra thickness. We may be pretty sure that they are not.

Is there any reason for the flukes to "prefer" a thicker shell than the snail does? Yes, I think a plausible case can be made, precisely because the flukes are not shouldering the economic burden. From the snail's point of view, the weighing up of costs and benefits can be thought of as a trade-off between survival and reproduction. A thicker shell means that the snail's own life expectancy is increased, but the economic costs of the thicker shell are felt as reduced reproductive success. Natural selection presumably arrives at an optimum balance.

But from the fluke's point of view the optimum balance looks different. The fluke is also inter- ested in the snail's survival, since its own survival is intimately bound up with the survival of its host (at least for a while). But the fluke has no specific interest in the reproductive success of its host. To be sure, it has a vague interest in the entire species of snails having reproductive success, so that there will be a new generation of snails to parsitize. But it has no specific interest in the reproductive success of its particular host, since the benefits of this to the next generation of flukes would be shared by all its rival flukes. As far as its particular host is concerned, it would be quite happy if that host were castrated. Indeed some parasites, as we know, do castrate their hosts, probably gaining benefits in the increased bodily growth of the host (Baudoin, 1975).

So, as far as snail shell thickness is concerned, there are two optima. The snail's optimum shell is thinner than the fluke's optimum. Switching, now, to gene language and the language of the extended phenotype, the snail phenotype is influenced not only by snail genes but also by fluke genes. These influences, to some extent, tug in opposite directions. The phenotype that we actually observe is probably a compromise between the two influences.

This is a slightly unfamiliar way of looking at life, so I will explain it in another way. Imagine three geneticists all doing research on the genetics of snail shell thickness. All three geneticists, in other words, are studying the same set of varying phenotypes. They differ with respect to the genes that they consider. One of the the three geneticists is a snail scientist. He studies the inheritance of shell thickness in pedigrees of snails. To him, the contribution of flukes to variations in the phenotype is strictly an environmental contribution to the variance. The second geneticist is a fluke geneticist. He studies the inheritance of host shell thickness in pedigrees of flukes. To him, the contribution of snail genes to variation in shell thickness is strictly an environmental contribution! I hope it is clear that both geneticists are practicing perfectly respectable genetics, albeit the fluke geneticist is a little unconventional. Yet each of them is relegating the genes studied by his colleague to the environmental category.

As you may have guessed, the resolution of this apparent paradox is achieved by the third geneticist. The third geneticist is an extended geneticist. He treats the variation in the shell phenotype as being under the joint influence of both snail genes and fluke genes. When you think about it, this is just what geneticists do all the time anyway, when they are studying genes within one genome. Geneticists are entirely accustomed to the idea that several genes influence the same phenotype. They normally think in terms of several genes of the "same" genome, but the whole point I am making is that there is nothing particularly special about the "same" genome. Fluke genes and snail genes can jointly influence the same phenotype, in just the same kind of way as snail genes and snail genes ordinarily interact with one another.

We have again reached our puzzle. Why do we assume that all the snail genes pull together as a team, while all the fluke genes pull together as a different team? The answer is not that there is anything qualitatively different about fluke genes and snail genes, some essence of snailiness or flukiness that pervades the substance of the genes. What, then, is the answer? The answer lies in the fact that the snail genes all share the same method of leaving the present snail body, and the fluke genes do not. The fluke genes in their turn all share the same method of leaving the present snail body, and the snail genes do not.

Why does the method of leaving the body matter so much? It matters because on it depends the series of events, in the future, from which the two sets of genes stand to gain. There is a partial overlap of interests. Both fluke genes and snail genes stand to gain from the snail's succeeding in finding food of the kind that best suits the snail's health. Both stand to gain from the snail's finding shelter from cold and other climatic hazards. Both, to a large extent at least, stand to gain from the snail's continuing to survive, But the two do not overlap in benefiting from the snail's reproducing. Snail genes that make the snail successful in finding a mate will be favored in the snail gene pool. Fluke genes that have the same effect on the snail will not be favored in the fluke gene pool.

In general, parasitologists should pay attention, above all other things, to the extent of overlap between methods of leaving the shared (host) body. Those parasites that put their gametes inside host gametes stand to gain from an almost identical set of future events to their host genes. They can therefore be expected to cooperate with their host as benign parasites or symbionts.

Some bacterial parasites of beetles not only live in the beetle's body. They also use the beetle's eggs as their transport into a new beetle. The genes of such a parasite therefore stand to gain from almost exactly the same set of future circumstances as the genes of their host. The two sets of genes, therefore, would be expected to pull together, for exactly the same reasons as all the genes of one organism pull together. It is irrelevant that some of them happen to be beetle genes while others happen to be bacterial genes. Both sets of genes are interested in the propagation of beetle eggs. Both sets of genes, therefore, are interested in making the beetle bodies successful in all departments of life, in both survival and reproduction. This is not true of the fluke genes and snail genes. The fluke genes care about snail survival, but not about snail reproduction. Therefore the cost/benefit calculations of snail genes and fluke genes come out differently. In the case of transovarial parasites like these bacteria, the cost/benefit calculations of host genes and parasite genes come out the same in all departments of life.

We now can take a radically unfamiliar view of any animal's "own" genes, and why they pull together for the good of all. The reason, quite simply, is that all expect to leave the present body by the same route as each other, by the same sperm or eggs. To be sure, in sexually reproducing organisms, not all genes get into all gametes. Indeed, each gene has only a 50-percent chance of getting into any given gamete. But all have the same statistical chance of getting into each gamete. As long as rogue genes do not cheat, and increase these odds - which some genes, the so-called segregation distorters, actually do (Crow, 1979) - all the genes stand to gain from the same set of events in the future. Fundamentally the reason is that meiosis is largely a fair, unbiased lottery.

This opens the new question of why meiosis is largely a fair, unbiased lottery. This is not a question I will tackle here. For now, I shall just accept that it is, and note what follows from it. The conclusion is that the genes of any one organism pull together for just the same reason as the genes of a transovarially transmitted bacterium pull together with the genes of its host. just as transovarially transmitted parasites are exceedingly "gentle" parasites - indeed not true parasites at all but mutualistic symbionts - so all the genes of a body can be regarded as gentle parasites of that body. The gentler the parasite, the more intimate the mutualism of a symbiotic relationship, and the less obvious it will be to us that it is a parasite at all. The parts will come to merge, until we cease to call the relationship parasitic or symbiotic, and think of the entire partnership as a single body. This is what has happened to mitochondria and other cell organelles, if Lynn Margulis's (1970) symbiotic theory is right. I want to go even further than Margulis, and regard all "normal" nuclear genes as symbiotic in the same kind of way as mitochondrial genes.

Parasites do not have to live inside their hosts. Cuckoos are perfectly good parasites, but they do not live inside their host's body, merely in its nest. They do not exploit the host's physiology directly, but indirectly via its behavior. But the principle is exactly the same, and the doctrine of the extended phenotype applies in the same kind of way.

It is easy to sympathize with the host foster parent when the cuckoo is at the egg stage. The eggs laid by a female of any one race closely resemble the eggs of the host species. The foster parent is fooled, in the same way as any victim of mimicry. We, can sympathize because human egg collectors - for such disreputable creatures were once, I regret to say, common - have frequently been fooled. We find it much harder to sympathize with the foster parent when the cuckoo youngster has grown near to the point of fledging. It seems to us the height of absurdity when we see a picture of a tiny reed warbler, standing on the back of its monstrous foster child in order to reach its huge open gape and drop food into it (Hamilton and Orians, 1965). Surely any fool could see that the nestling cuckoo is not a reed warbler. It is one thing to be fooled by subtle egg mimicry, but who could be fooled by a fake child seven times the size of the real thing? Putting the problem in a less subjective and more Darwinian way, how can natural selection be so efficient in perfecting the egg mimicry of the cuckoo, yet so inefficient in allowing grossly oversized nestlings to survive their foster parents' discrimination?

The problem is lessened by the following consideration. The cost of failure, from the point of view of the foster parent, is less at the egg stage of the cuckoo than at the nestling stage. A reed warbler who succeeds in detecting a cuckoo egg gains an entire breeding season. A reed warbler who succeeds in detecting a nearly fledged cuckoo has little to gain, since the season is nearly over anyway. But, even so, it seems hard to believe that a visual system sharp enough to detect the mimicry of cuckoo eggs could be "stupid" enough to be fooled by a cuckoo fledgling.

Perhaps "fooled" is the wrong word. A human male may be sexually aroused, even physiologically aroused, by a photograph or drawing of a female. Suppose a Martian ethologist observed this phenomenon. Would he say: "How silly to be fooled by this fake woman. Surely anyone can see that she is only a pattern of printing ink on paper, and only about a tenth of natural size. " Men of course are not actually "fooled" by the picture. They do not really think it is a woman. They simply find themselves aroused by it in the same kind of way as they might be by a real woman. Perhaps something like this is true of the cuckoo's foster parent. There are many well-documented observations of adult birds, of many species, flying home with food for their own young, and being diverted by the chance sighting of a gaping cuckoo nestling in another bird's nest. They then feed the cuckoo in the other bird's nest, in apparent preference to their own young in their own nest. Perhaps the cuckoo nestling is, as Oskar Heinroth is reported to have said, a "vice" of its foster parents. He said that the parents behave like "addicts. " Is the colored gape of the young cuckoo like an irresistible drug? Following Dawkins and Krebs (1978) and Krebs and Dawkins (1984), I want to make the general case that animals may manipulate other animals with weapons that we can best understand if we think of metaphors like "drugs" and "hypnosis. Keith Nelson once gave a talk about bird song entitled: "Is bird song music? Well, then, is it language? Well, then, what is it?" I want to make the case that, at least in some cases, it may be akin to hypnotic persuasion, spellbinding oratory, hauntingly irresistible music. The poet Keats wrote, in his Ode to a Nightingale,

My heart aches, and a drowsy numbness pains My sense, as though of hemlock I

had drunk, Or emptied some dull opiate to the drains One minute past, and

Lathe-wards had sunk. What I am suggesting is that nightingale song, cuckoo gapes, and many pheromones perhaps are exerting an influence on their receivers' ner- vous systems which is irresistible in the same kind of way as a drug may be irresistible. Or as the electric currents of a neurophysiologist may be irresistible. A neurophysiologist can implant electrodes in carefully chosen parts of the brain of a cat or a chicken and, by passing current down them, manipulate the behavior of the animal like a puppeteer pulling strings. If the brain is vulnerable to such manipulation, should not natural selection, working on other animals, have perfected the power to manipulate? To be sure, animals cannot literally bore holes in one another's brains, cannot literally pass electric current in. But there are convenient holes already bored: eyes, ears, and noses. They provide ready-made channels into the deep parts of the brain and they are, in some senses, predisposed to be manipulated. A reed warbler's brain already has the predisposition to be attracted to the open gapes of it,,; own young. The young cuckoo has only to tap into this ready-made channel into the brain, and it apparently is not all that difficult to go one better and evolve a supernormal stimulus. Natural selection would surely favor animals that succeed in manipulating the nervous systems of other animals in this kind of way.

The obvious question now stands out. Why do victims of manipulation stand for it? Just as natural selection would favor manipulators who discover and exploit portholes into the brains of their victims, so natural selection will favor those would-be victims who close off those very portholes. How can there be any long-term future in manipulation as a way of life? One possible answer is that there is not any long-term future. It could be that cuckoos can survive only by exploiting evolutionary time lags. Perhaps cuckoos can exploit any one host species for only a few centuries, before the host gene pool accumulates enough genes for resisting manipulation. Then selection in the cuckoo gene pool favors those who start exploiting a new species which is still, evolutionarily speaking, naive about the dangers of being manipulated, There is some direct evidence that this may be at least a part of the truth (N. B. Davies and M. de L. Brooke, in preparation). But I doubt if it is the whole truth. I think we also need to consider the theory of evolutionary arms races, and how they may end (Dawkins and Krebs, 1979).

An evolutionary arms race is a process of co-evolution in which advances on one side are matched by counter-advances on the other, which in turn provoke further advances on the first side, and so on. Arms races are common between predators and prey, and parasites and hosts, and are one of the principal forces driving towards progressive evolution of ever more complex and sophisticated biological armament and instrumentation (Dawkins, 1986). As so far described, there seems no obvious way for an arms race to end. But this is too simple. We have left economics out of the discussion. Arms races do not, in any case, make sense without economic considerations.

There are economic and other costs to each side in each advance in the arms race. For a deer to evolve faster running, for example, it must develop bigger muscles. This means spending more resources on muscle tissue, resources which could have been spent on, say, reproduction. There will be some optimum compromise between amount spent on leg muscles and amount spent on reproduction. Any individual deer that spends less than the optimum will be vulnerable to being eaten. But also, any individual deer that spends more than the optimum will be less reproductively successful than an individual spending the optimum amount. The overspender, to be sure, may live longer as an individual. But it will not pass so many genes on to future generations, so genes for overspending will not increase in the gene pool. If it were not for such economic considerations, all animals would run as fast as cheetahs and would be as clever as humans.

Now, what happens to this optimum if there is an arms race going on? If the predators increase their running speed, there will be a shift in the timum balance within the deer gene pool. Individuals that previously would have been classed as overspenders now propagate more genes than individuals that previously would have been classified as optimal. So the deer population takes a step in the direction of greater average running speed. This in turn changes the optimum in the predator population, and so on.

But now, what if there are asymmetries in the economic calculations on the two sides of the arms race? Two thousand years ago, Aesop noted that the rabbit runs faster than the fox, because the rabbit is running for his life, while the fox is only running for his dinner. The cost of failure in running speed, for the fox, is merely a lost dinner. The cost of failure in running speed, for the rabbit, is a lost life. In the trade-off between spending resources on leg muscles and on reproduction, therefore, the optimum for the fox population could well come out very different from the optimum for the rabbit population.

We can apply this kind of economic thinking to the case of cuckoo nestlings manipulating their foster parents. The cost of failure to a young cuckoo is death. The cost of failure to a foster parent is the loss of part of one breeding season. To put it another way, the cuckoo is descended from a long line of ancestors, every single one of whom has succeeded in manipulating a foster parent. The foster parent is descended from a long line of ancestors, only a proportion of which ever met a cuckoo in their lives, and even that proportion had another chance to reproduce after failing in that one year. Maybe the arms race between cuckoos and reed warblers has ended in a kind of stable compromise.

If there are economic costs to a reed warbler in resisting manipulation by cuckoos, it is even possible that natural selection among reed warblers favors complete capitulation. if cuckoos, for instance, were rare, then any individual reed warbler that was prepared, genetically speaking, to pay the cost of resistance, might actually be less successful than a rival individual that made no attempt whatever to resist cuckoos. Total nondiscrimination could be, for economic reasons, a better policy than costly discrimination, even though nondiscrimination carries the risk of parasitization.

If animals can manipulate other animals, and if the economics of arms races leads to stable equilibria in which the victims of manipulation acquiesce in being manipulated, we once again arrive at the same conclusion as before. When a behavioral ecologist looks at some feature of an animal's behavior, or anatomy, he should not necessarily ask, "How does this feature benefit the animal?" Instead, he should ask, "Which animal is this feature benefiting?" Whereas, before, the hidden manipulator behind the scenes was assumed to be a parasite inside the host's body, with direct access to the host's physiology and biochemistry, we have now extended our view to include manipulators outside the victim's body. The manipulator can even be a long way away, manipulating its victim by sound, or by chemical means.

I can summarize the extended phenotype view of life by contrasting it with two others in the form of diagrams. The two others can conveniently be labeled with the names of the great biologists who advocated them, Lamarck and Weismann. In the Lamarckian view of life (actually Lamark simply adopted a prevailing view of his contemporaries and predecessors, but his name is conveniently used as a label), bodies pass on their attributes to descendant bodies fig. 1). Hence new characteristics acquired during the body's life can be passed on. The Lamarckian view was replaced by the Weismannian view, according to which the germ-lines (we should now say the genes) are passed down the generations, influencing bodies as a side issue. A very important side issue, it has to be hastily said, since the survival or nonsurvival of the genes largely depends upon their effects upon bodies. The extended phenotype view of life (fig. 3) is an extension of the Weismannian view. Indeed, I would maintain that it takes Weismannism to its logical conclusion. There is still an immortal germ-line, and genes still survive or perish by virtue of their phenotypic consequences. But those phenotypic consequences are no longer limited to the body in which the genes are sitting. Genetic influences reach out beyond the body of the individual organism and affect the world outside, both the inanimate world and other living organisms. Coevolution, and the interaction between organisms, is best seen as an interlocking web of extended phenotypes. Literature CITED

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Why don’t animals have wheels?

by Richard Dawkins
Article in The Sunday Times, November 24th 1996

The wheel is the archetypal, proverbial, human invention. We don’t just travel on wheels, it is wheels – forgive me – that make the world go round. Take apart any machine of more than rudimentary complexity and you’ll find wheels. Ship and aeroplane propellors, spinning drills, lathes, potters’ wheels – our technology runs on the wheel and would seize up without it.

The wheel may have been invented in Mesopotamia during the fourth millennium BC. We know it was elusive enough to need inventing, because the New World civilisations stilll lacked it by the time of the Spanish conquest. The alleged exception there – children’s toys – seems so bizarre as to prompt suspicion. Could it be one of those false legends, like eskimos having 50 words for snow, which spreads purely because it is so memorable?

Whenever humans have a good idea, zoologists have grown accustomed to finding it anticipated in the animal kingdom.. Why not the wheel? Bats and dolphins perfected sophisticated echo-ranging systems millions of years before human engineers gave us sonar and radar. Snakes have infra-red heat detectors for sensing prey, long pre-dating the Sidewinder missile. Two groups of fish, one in the New World and one in the Old, have independently developed the electric battery, in some cases delivering currents strong enough to stun a man, in other cases using electric fields to navigate through turbid water. Squids have jet propulsion, enabling them break the surface at 45 m.p.h. and shoot through the air. Mole crickets have the megaphone, digging a double horn in the ground to amplify their already astonishingly loud song. Beavers have the dam, flooding a private lake for their own safe-conduct over water.

Fungi developed the antibiotic (of course, that’s where we get penicillin from). Millions of years before our agricultural revolution, ants planted, weeded and composted their own fungus gardens. Other ants tend and milk their own aphid cattle. Darwinian evolution has perfected the hypodermic needle, the valved pump, the fishing net, the harpoon, the fishing rod, the water pistol, the automatic focus lens, the lightmeter, the thermostat, the hinge, the clock and the calendar. Why not the wheel?

Now, it is possible that the wheel seems so marvellous to us only by contrast with our rather undistinguished legs. Before we had engines driven by fuels (fossilised solar energy), we were easily outpaced by animal legs. No wonder Richard III offered his kingdom for four-footed transportation out of his predicament. We show up poorly against two-legged runners, too, in the form of ostriches and kangaroos. Perhaps most animals wouldn’t benefit from wheels because they can already run so fast on legs. After all, until very recently, all our wheeled vehicles have been pulled by leg power. We developed the wheel, not so as to go faster than a horse, but so as to enable a horse to transport us at its own pace – or a bit less. To a horse, a wheel is something that slows you down.

Here’s another way in which we risk over-rating the wheel. It is dependent for maximum efficiency on a prior invention – the road (or other smooth, hard surface). A car’s powerful engine enables it to beat a horse or a dog or a cheetah on a hard, flat road, or smooth, iron rails. But run the race over wild country or ploughed fields, perhaps with hedges or ditches in the way, and it is a rout: the horse will leave the car wallowing. Size for size, a running spider is surely faster than any wheeled vehicle over any terrain.

Well then, perhaps we should change our question. Why haven’t animals developed the road? There is no great technical difficulty. The road should be childsplay compared with the beaver dam or the bower-bird’s ornamented arena. There are even some digger wasps that tamp soil hard, picking up a stone tool to do so. Presumably the same skills could be used by larger animals to flatten a road.

Now we come to an unexpected problem. Even if roadbuilding is technically feasible, it is a dangerously altruistic activity. If I as an individual build a good road from A to B, you may benefit from the road just as much as I do. Why should this matter? This raises one of the most tantalising and surprising aspects of all Darwinism, the aspect that inspired my first book, The Selfish Gene. Darwinism is a selfish game. Building a road that might help others will be penalised by natural selection. A rival individual benefits from my road just as much as I do, but he does not pay the cost of building.

Darwinian selection will favour road building only if the builder benefits from the road more than his rivals. Selfish parasites, who use your road and don't bother to build their own, will be free to concentrate their energy on outbreeding you, while you slave away on the road. Unless special measures are taken, genetic tendencies towards lazy, selfish exploitation will thrive at the expense of industrious roadbuilding. The upshot will be that no roads get built. With the benefit of foresight, we can see that everybody will be worse off. But natural selection, unlike we humans with our big, recently evolved brains, has no foresight.

What is so special about humans that we have managed to overcome our antisocial instincts and build roads that we all share. We have governments, policed taxation, public works to which we all subscribe whether we like it or not. The man who wrote, "Sir, You are very kind, but I think I'd prefer not to join your Income Tax Scheme", heard again, we may be sure, from the Inland Revenue. Unfortunately, no other species has invented the tax. They have, however, invented the (virtual) fence. An individual can secure his exclusive benefit from a resource if he actively defends it against rivals.

Many species of animals are territorial, not just birds and mammals, but fish and insects too. They defend an area against rivals of the same species, often so as to sequester a private feeding ground, or a private courtship bower or nesting area. An animal with a large territory might benefit by building a network of good, flat roads across the territory from which rivals were excluded. This is not impossible, but such animal roads would be too local for long distance, high speed travelling. Roads of any quality would be limited to the small area that an individual can defend against genetic rivals. Not an auspicious beginning for the evolution of wheel.

Now I must mention that there is one revealing exception to my premiss. Some very small creatures have evolved the wheel in the fullest sense of the word. One of the first locomotor devices ever evolved may have been the wheel, given that for most of its first two billion years, life consisted of nothing but bacteria (and, to this day, not only are most individual organisms bacteria, even in our own bodies bacterial cells greatly outnumber our 'own' cells).

Many bacteria swim using threadlike spiral propellors, each driven by its own continuously rotating propellor shaft. It used to be thought that these 'flagella' were wagged like tails, the appearance of spiral rotation resulting from a wave of motion passing along the length of the flagellum, as in a wriggling snake. The truth is much more remarkable. The bacterial flagellum is attached to a shaft which, driven by a tiny molecular engine, rotates freely and indefinitely in a hole that runs through the cell wall.

Picture (see suggestions faxed separately to Jeremy Bayston)

The fact that only very small creatures have evolved the wheel suggests what may be the most plausible reason why larger creatures have not. It's a rather mundane, practical reason, but it is nonetheless important. A large creature would need large wheels which, unlike manmade wheels, would have to grow in situ rather than being separately fashioned out of dead materials and then mounted. For a large, living organ, growth in situ demands blood or something equivalent. The problem of supplying a freely rotating organ with blood vessels (not to mention nerves) that don't tie themselves in knots is too vivid to need spelling out!

Human engineers might suggest running concentric ducts to carry blood through the middle of the axle into the middle of the wheel. But what would the evolutionary intermediates have looked like? Evolutionary improvement is like climbing a mountain ("Mount Improbable"). You can't jump from the bottom of a cliff to the top in a single leap. Sudden, precipitous change is an option for engineers, but in wild nature the summit of Mount Improbable can be reached only if a gradual ramp upwards from a given starting point can be found. The wheel may be one of those cases where the engineering solution can be seen in plain view, yet be unattainable in evolution because its lies the other side of a deep valley, cutting unbridgeably across the massif of Mount Improbable.

Richard Dawkins is the Charles Simonyi Professor of the Public Understanding of Science at Oxford University (see http://www.spacelab.net/~catalj/home.html). His books include The Selfish Gene, The Blind Watchmaker, River Out of Eden and, most recently, Climbing Mount Improbable (Viking, 1996).

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Why I am a secular humanist. (views of members of the International Academy of Humanism)(includes related article on secular humanist Sir Isaiah Berlin) Yelena Bonner; Hermann Bondi; Taslima Nasrin; Richard Dawkins; Richard Taylor; John Passmorre; Arthur C. Clarke; Anthony Flew; J.J.C. Smart; Inumati Parikh.

Abstract: Several members of the International Academy of Humanism presented their views on being secular humanists. Some of them believed that their professions, family backgrounds and ideals positively contribute to the values embodied by humanism. They felt that their views correlate well with issues of faith, double standards, and religion. Other members of the academy associated their commitments, ethical conduct and philosophy with various human life issues and concerns.

The members of the International Academy of Humanism reflect on the guiding principles of their lives

The International Academy of Humanism was established in 1985 to recognize distinguished humanists and to disseminate humanistic ideals and beliefs.

YELENA BONNER

A distinguished defender of human rights. Because of her human rights advocacy in the former USSR, she was persecuted by the state, as was her late husband, Andrei Sahkarov, the famous Soviet dissident and Nobel Peace Laureate.

I was born in 1923 and grew up in a time when the word humanism and all concepts that accompanied it were scorned and rejected as bourgeois vocabulary. A common phrase stated that "a communist cannot be a humanist." Many years later, in a Soviet encyclopedic dictionary, I read: ". . . Karl Marx called communism 'real humanism.' Humanism received practical realization in the achievements of socialism, that pronounced as its principle "All for the sake of man, for the good of man."

It was both ridiculous and sad to read this in Gorky, where my husband, Andrei Sakharov, was kept in isolation from the entire world by the whim and arbitrariness of the authorities, and where I was sentenced to exile four years later.

My perception of good and evil were shaped and nurtured by my family, friends, and colleagues. I was 14 years old when my parents were arrested. My father was shot, and my mother was taken away from me and my younger brother for eight years of labor camps and another nine years of internal exile, until the time when the so-called violations of socialist legality were condemned in my country and my parents were exonerated, my father posthumously. Such was communist "humanism."

My family's tragedy did not make me bitter, and I have never held it against my country, never felt my country was culpable. Rather, it was perceived as an act of god, especially since the case of my family was not unique. The same fate had befallen many of my peers - friends and schoolmates. All of us were "strange orphans of 1937," to use the expression coined by the writer Ilya Ehrenburg. In reality "strange orphans" in our society existed since 1917, as well as much later than 1937.

There is no doubt that my family's misfortune left a mark on my psyche, but to all that was evil there was a counterweight in the great Russian literature, and particularly, in poetry, which was fortunately close to my heart from early childhood. Then came World War II with its blood and suffering, with terrible injustice of young lives cruelly cut short - lives of strangers and the most dear ones alike. There was fear. Survival seemed a miracle. A poet's line fully applies to me: "I put the war past me, but it passed through me."

After the war I betrayed my first choice of vocation (I had volunteered to the front after my freshman year of study in Russian language and literature) and entered medical school. I wanted to do good not by word but deed, by everyday work. I have never regretted having become a physician. Even today I relive the sensation of happiness that accompanies the first cry of a newborn in the delivery room; or when entering the ward I would hear two or three dozen babies crying in unison, for feeding time was near. I often found myself smiling as I walked toward their cries. A crying baby is an alive baby.

It was in the family with its misfortunes and joys, in friends and books, in professional life, in the concerns of a woman and a mother that I developed my own perception of the world and of my place in it, my ideals. In essence, they are probably close to the values of humanism.

Translated by Taliana Yakelerich

EDWARD O. WILSON

Emeritus Professor of Entomology at Harvard University and author of numerous widely acclaimed books including Sociobiology.

I was raised a Southern Baptist in a religious environment that favored a literal interpretation of the Bible. But it happened that I also became fascinated by natural history at an early age, and, as a biology concentrator at the University of Alabama, discovered evolution. All that I had learned of the living world to that point fell into place in a wholly new and intellectually compelling way. It was apparent to me that life is connected not by supernatural design but by kinship, with species having multiplied out of other species to create, over hundreds of millions of years, the great panoply of biodiversity around us today. If a Divine Creator put it all here several thousand years ago, he also salted Earth from pole to pole with falsified massive, interlocking evidence to make scientists believe life evolved autonomously. I realized that something was terribly wrong in this dissonance. The God depicted in Holy Scripture is variously benevolent, didactic, loving, angry, and vengeful, but never tricky.

As time passed, I learned that scientific materialism explains vastly more of the tangible world, physical and biological, in precise and useful detail, than the Iron-Age theology and mysticism bequeathed us by the modern great religions ever dreamed. It offers an epic view of the origin and meaning of humanity far greater, and I believe more noble, than conceived by all the prophets of old combined. Its discoveries suggest that, like it or not, we are alone. We must measure and judge ourselves, and we will decide our own destiny.

Why then, am I a humanist? Let me give the answer in terms of Blaise Pascal's Wager. The seventeenth-century French philosopher said, in effect, live well but accept religious faith. "If I lost," he wrote. "I would have lost little: If I won I would have gained eternal life." Given what we now know of the real world, I would turn the Wager around as follows: if fear and hope and reason dictate that you must accept the faith, do so, but treat this world as if there is none other.

SIR HERMANN BONDI

Fellow of the Royal Society and past Master of Churchill College, Cambridge University.

I grew up in Vienna in a nonbelieving Jewish family. But whereas my father liked the forms of the Jewish religion as a social cement (and indeed we kept the household such that we could entertain our numerous Orthodox relatives), I acquired from my mother an intense dislike of the narrowness and exclusivity of the religion. Ethical principles were very strong at home. I soon became clear to me that a moral outlook was at least as strong among nonbelievers. I similarly acquired a strong dislike of the alternative religion, the Catholic Church (in Austria dominant and very reactionary). So I was set early on the path of nonbelief, with strong ethical principles, and soon was ready to declare my attitude. But it was only later that I joined others with a similar outlook in humanist organizations.

My opinion now is that arguments about the existence or nonexistence of an undefined "God" are quite pointless. What divides us from those who believe in one of the faiths claiming universal validity (such as Christianity or Islam) is their firm trust in an alleged revelation. It is this absolute reliance on a sacred text that is the basis of the terrible crimes committed in the name of religion (and of other absolutist faiths such as

Nazism or doctrinaire communism). It is also worth pointing out the appalling arrogance of viewing one's own religion as "right" and all others as "wrong." The multiplicity of mutually contradictory faiths needs pointing out again and again.

Thus I regard humanism not as yet another exclusive faith, but as a determination to stress those issues on which we are all more or less agreed and to relegate to the backburner faiths that divide us. Thus I am a firm secularist, favoring a society and educational system in which those of any religion and of none can feel comfortable as long as they are not aggressive or separatist.

TASLIMA NASRIN

A physician-turned-human-rights-activist and author of the dissident novel Shame. She is exiled from her native Bangladesh.

I was born in a Muslim family. I was forced by mother to read the Koran every morning, to pray namaz, and to fast during Ramadan.

While I was growing up, I was taken by my mother to a pit, a religious cult leader respected by Muslims. He had his own group, who believed in a genie and superstitions. The pit declared that women who laughed in front of men and went out of the house had been taken over by the genie and they were brutally beaten by the pit so that the genie would leave. He gave a scary description of hell. Whoever visited him gave money.

The pir was surrounded by young women who massaged his body and served him whatever he needed. One day, in my presence, he declared that keyamout, the destruction day of the Earth, was coming soon, and that there was no need for women to marry. They should sacrifice their lives for Allah.

I was' horrified to see all the torture he did to get rid of the genie and to listen to the description of hell and waiting for keyamout. But it did not come.

The pir used to treat sick people by uttering sura and beating them. Water was declared holy and said to cure sick people. The sick became sicker after drinking the water. I was also treated by a pit, but I was not cured until my physician father treated me with scientific medicine.

I was encouraged by my father to get a secular education. I learned about the big bang, evolution, and the solar system and became suspicious about Allah's six-day adventure to make the whole universe, the Adam and Eve story, and stories of suns moving around the Earth and mountains like nails to balance the Earth so that the Earth would not fall down. My mother asked me not to ask any questions about Allah and to have blind faith in Allah. I could not be blind.

Then I studied the Koran instead of reading it without knowing the meaning. I found it total bull-shit. The Koran, believed by millions, supported slavery and inequalities among people - in other countries the equality of women had been established as a human right and the moon had already been won by men. Men had the right to marry four times, divorce, have sex with female slaves, and beat their wives. Women were to hide their bodies because the female body is simply a sexual object. Women were not allowed to divorce their husbands, enjoy inheritance, or have their testimony in court considered as seriously as men's. I found that Allah prescribed Muslims to hate non-Muslims and kill apostates.

With my own conscience I found religion ridiculous because it stops freethought, reason, and rationality. My father told me to believe nothing without reason. I did that. I could not believe religion and I became an atheist. I started writing against religion and all the religious superstitions. I was attacked, verbally, physically. The outrage of the religious people was so big that I had to leave my country.

I lived in one of the poorest countries in the world. I saw how poverty was glorified by religion and how the poor are exploited. It is said the poor are sent to the Earth to prove their strong faith for Allah in their miserable life. I have not seen any religious teaching that calls for a cure for poverty. Instead the rich are supposed to make Allah happy by giving some help (Mother Teresa's type of help). The poor should remain poor in society, and opportunists can use them to buy a ticket for heaven.

So I don't accept Allah, His cruel unholiness. I have my own conscience, which inspired me to support a society based on equality and rationality. Religion is the cause of fanaticism, bloodshed, hatred, racism, conflict. Humanism can only make people humane and make the world livable.

RICHARD DAWKINS

Charles Simionyi Professor of Public Understanding of Science, Oxford University, and author of The Blind Watchmaker, The Selfish Gene, and Climbing Mount Improbable.

It is said that, while science can answer many of our questions, it cannot answer all of them. True. But false is the hidden implication that if science can't answer a question it follows that some other discipline can.

Certainly science cannot prove what is right or wrong, but nor can theology. Secular, rationalistic, moral philosophy comes closest by exposing our inconsistencies and double standards.

But science can answer deep questions popularly regarded as outside its remit, as well as those that are universally ceded to it. "Why is there anything rather than nothing?" is often cited as beyond the reach of science, but physics may one day answer it and if physics doesn't, nothing will.

"What is the purpose of life?" already has a straightforward Darwinian answer and is quite different from "What would be a worthwhile purpose for me to adopt in my own life?" Indeed, my own philosophy of life begins with an explicit rejection of Darwinism as a normative principle for living, even while I extol it as the explanatory principle for life.

This brings me to the aspect of humanism that resonates most harmoniously for me. We are on our own in the universe. Humanity can expect no help from outside, so our help, such as it is, must come from our own resources. As individuals we should make the most of the short time we have, for it is a privilege to be here. We should seize the opportunity presented by our good fortune and fill our brief minds, before we die, with understanding of why, and where, we exist.

I'd worry about the humanist label if it implied something uniquely special about being human. Evolution is a gradual process. Humanness is not an all-or-none quality that you either have or don't have. It is a complicated mixture of qualities that evolved gradually, which means that some people have higher doses than others, and some nonhumans have non-negligible doses as well. Absolutist moral judgments founded on the "rights" of all humans, as opposed to nonhumans, therefore seem to me less justifiable than more pragmatic judgments based, for example, on quantitative assessment of the ability to suffer.

The atheist label also worries me because it shouldn't be necessary. Those who don't believe in fairies have no need of a label: the onus of proof is on those who do. I would with positive conviction call myself a scientific rationalist, with a humane concern that is directed toward a target that is both wider and narrower than humanity. Wider because it includes other species and potentially other planets. Narrower because it admits that not all humans are equal.

RICHARD TAYLOR

Professor Emeritus of Philosophy, University of Rochester, and author of Metaphysics.

I am interested in humanism, not as a creed or set of beliefs, but simply as social policy and a way of treating people. Essentially, it is a way of making the conditions of life less burdensome, the relationships between people more fulfilling, and promoting harmony rather than friction. People fare best when they look not to moral rules and principles, not to priests and churches, and not to creeds, but to the actual results of what they do.

Three things have guided me to this approach to life. The first is the wisdom of Socrates, especially as it was developed by the Stoic philosophers of Antiquity and then by such modern Stoics as Henry David Thoreau. They all taught us that we should look first to our own nobility as rational human beings and pay little attention to such things as wealth or power. The second was the philosophy of Arthur Schopenhauer, who located all ethical conduct in our capacity for compassion, not only for other human beings, but for all things that feel pain. And the third was the extraordinary achievements of Joseph Fletcher, whom it was one of my great blessings to know as a friend.

JOHN PASSMORE

Emeritus Professor of Philosophy at Australian National University and President of the Australian Academy of Science. His book Memoirs of a Semidetached Australian details his evolution from Roman Catholicism.

I rebelled as a young boy against the view that the whole of humanity suffers because a single person was disobedient. This I saw as tyranny of the first order. If there was no salvation outside the Roman Catholic Church, I also argued, how could an omnipotent God allow our aborigines to remain unsaved for thousands of years, when they knew nothing of the Church? Later, under the influence of my university philosophy teacher I developed metaphysical arguments against religion.

Critics of humanism sometimes suggest that we make a god of man. But I am willing to admit that there is no deed so dreadful that we can safely say "no human being could do that" and no belief so absurd that we can safely say "no human being could believe that." But on the other side I point to the marvelous achievements of human beings in science and art and acts of courage, love, and self-sacrifice.

I call myself a pessimistic humanist because I do not regard human beings or their societies as being perfectible but a humanist I nonetheless am. And I reflect on the fact that the worst terrorists of the dreadful century I have lived through have felt justified by their belief that they are acting in the interests of some superhuman entity, whether it be God, or History, or the State.

ARTHUR C. CLARKE

Well-known science-fiction writer, author of 2001: A Space Odyssey, and respected futurist.

The greatest tragedy in mankind's entire history may be the hijacking of morality by religion. However valuable - even necessary - that may have been in enforcing good behavior on primitive peoples, their association is now counterproductive. Yet at the very moment when they should be decoupled, sanctimonious nitwits are calling for a return to morals based on superstition. Virtually all civilized societies would give a passing grade of at least 60% to the Ten Commandments (modern translation: "suggested guidelines"). They have nothing to do with any specific faith.

ANTONY FLEW

Professor Emeritus of Philosophy at Reading University in the United Kingdom. His books include The Logic of Mortality and Atheistic Humanism.

My father, like his father before him, was a Methodist minister. At the age of 13, I was sent to the excellent boarding school founded by John Wesley for the education of the sons of his itinerant preachers. I originally rejected the Christian faith - a rejection that occasioned distress to all concerned-during my middle teens. I rejected it then simply and solely because I had come to believe that it could not be true: the belief that the universe is created and sustained by a being both omnipotent and benevolent seemed to me, as it still seems, manifestly incompatible with innumerable, all-too familiar facts. Now - 60 years on - I am more inclined to argue on Humean lines that there is no good evidencing reason for making positive assertions about the putative Cause of the Universe.

J. J. C. SMART

Professor of Philosophy at Australian National University. He recently defended atheism in a debate with J. J. Haldane in the book Atheism and Theism.

My parents were Scots, but I was born and grew up in Cambridge. We were Presbyterians, and I went to a Methodist school. However, on moving to Glasgow, where my father became Regius Professor of Astronomy, my mother, who in Cambridge had some hankering for the Anglican church, became a Scottish Episcopalian and in this was followed by my brothers and then by my father. Last of all I became an Anglican at Oxford.

Nevertheless, I felt uneasy in my churchgoing because I increasingly found it hard to reconcile it with my scientific and philosophical beliefs. I comforted myself with Wittgensteinian double-talk, of which I now feel thoroughly ashamed. For emotional reasons, connected with my affection for my parents, I was a reluctant atheist, but giving up religion brought peace of mind because intellectual conflict was resolved.

INDUMATI PARIKH

Physician and President of the Indian Radical Humanist Association.

In our society woman is on the lowest rung of the social ladder. She does not have freedom to assert herself in fact, she hardly knows what freedom is. So it is the case with most of our poor ignorant men. I thought helping women to be free was more important and would have a lasting effect on the community. In a society fragmented by religion and castes, I thought humanism was the only ideology that would cut across boundaries and help men and women to understand their basic humanness. Being more of an activist than a philosopher, I put my energy to helping women, children, and men at the lowest end of society. I might be one of the few who have worked at developing humanism through work at grassroots level.

Sir Isaiah Berlin, Secular Humanist

When Isaiah Berlin died at 88 on November 5, 1997, the International Academy of Humanism lost one of its most distinguished members - and the world was deprived of a great mind both humane and fecund. The least of his achievements was that he had received 23 honorary doctorates, numerous academic awards, the Order of Merit, and knighthood. The greatest was that he was a philosopher and historian of ideas who spent his life promoting and refining humanist ideals: liberty, social pluralism, critical thought, and the dignity of human beings. Along the way, he attained a passionate life filled with the delights of the intellect, of music, of good conversation, and of friends.

Wonderful Life by Stephen J. Gould. Reviewed by Richard Dawkins in Sunday Telegraph, 25th Feb 1990

If only Stephen Gould could think as clearly as he writes! This is a beautifully written and deeply muddled book. To make unputdownable an intricate, technical account of the anatomies of worms, and other inconspicuous denizens of a half-billion-year-old sea, is a literary tour-de-force. But the theory that Gould wrings out of his fossils is a sorry mess.

The Burgess Shale, a Canadian rock formation dating from the Cambrian, the earliest of the great fossil eras, is a zoological treasury. Freak conditions preserved whole animals, soft parts and all, in full 3-D. You can literally dissect your way through a 530-million-year-old animal. C D Walcott, the eminent palæontologist who discovered the Burgess fossils in 1909, classified them according to the fashion of his time: he ‘shoehorned’ them all into modern groups. ‘Shoehorn’ is Gould’s own excellent coining. It recalls to me my undergraduate impatience with a tutor who asked whether the vertebrates were descended from this invertebrate group or that. "Can’t you see", I almost shouted, "that our categories are all modern? Back in the Precambrian, we wouldn’t have recognized those invertebrate groups anyway. You are asking a non-question." My tutor agreed, and then went right on tracing modern animals back to other modern groups!

That was shoehorning, and that is what Walcott did to the Burgess animals. In the 1970s and 80s, a group of Cambridge palæontologists returned to Walcott’s museum specimens (with some newer collections from the Burgess site), dissected their 3-dimensional structure, and overturned his classifications. These revisionists, principally Harry Whittington, Derek Briggs and Simon Conway Morris, are the heroes of Gould’s tale. He milks every ounce of drama from their rebellion against the shoehorn, and at times he goes right over the top: "I believe that Whittington’s reconstruction of Opabinia in 1975 will stand as one of the great documents in the history of human knowledge."

Whittington and his colleagues realised that most of their specimens were far less like modern animals than Walcott had alleged. By the end of their epic series of monographs they thought nothing of coining a new phylum for a single specimen (‘phylum’ is the highest unit of zoological classification; even the vertebrates constitute only a sub-category of the Phylum Chordata). These brilliant revisions are almost certainly broadly correct, and they delight me beyond my undergraduate dreams. What is irritating is Gould’s grandiloquent and near-disingenuous usage of them. He concludes that the Burgess fauna was demonstrably more diverse than that of the entire planet today, he alleges that his conclusion is deeply shocking to other evolutionists, and he thinks that he has upset our established view of history. He is unconvincing on the first count, clearly wrong on the second two.

In 1958 the palæontologist James Brough published the following remarkable argument: evolution must have been qualitatively different in the earliest geological eras, because then new phyla were coming into existence; today only new species arise! The fallacy is glaring: every new phylum has to start as a new species. Brough was wielding the other end of Walcott’s shoehorn, viewing ancient animals with the misplaced hindsight of a modern zoologist: animals that in truth were probably close cousins were dragooned into separate phyla because they shared key diagnostic features with their more divergent modern descendants. Gould too, even if he is not exactly reviving Brough’s claim, is hoist with his own shoehorn.

How should Gould properly back up his claim that the Burgess fauna is super-diverse? He should - it would be the work of many years and might never be made convincing - take his ruler to the animals themselves, unprejudiced by modern preconceptions about ‘fundamental body plans’ and classification. The true index of how unalike two animals are is how unalike they actually are! Gould prefers to ask whether they are members of known phyla. But known phyla are modern constructions. Relative resemblance to modern animals is not a sensible way of judging how far Cambrian animals resemble one another.

The five-eyed, nozzle-toting Opabinia cannot be assimilated to any textbook phylum. But, since textbooks are written with modern animals in mind, this does not mean that Opabinia was, in fact, as different from its contemporaries as the status ‘phylum’ would suggest. Gould makes a token attempt to counter this criticism, but he is hamstrung by dyed-in-the-wool essentialism and Platonic ideal forms. He really seems unable to comprehend that animals are continuously variable functional machines. It is as though he sees the great phyla not diverging from early blood brothers but springing into existence fully differentiated.

Gould, then, singularly fails to establish his super-diversity thesis. Even if he were right, what would this tell us about ‘the nature of history’? Since, for Gould, the Cambrian was peopled with a greater cast of phyla than now exist, we must be wonderfully lucky survivors. It could have been our ancestors who went extinct; instead it was Conway Morris's 'weird wonders', Hallucigenia, Wiwaxia and their friends. We came 'that close' to not being here.

Gould expects us to be surprised. Why? The view that he is attacking - that evolution marches inexorably towards a pinnacle such as man - has not been believed for 50 years. But his quixotic strawmandering, his shameless windmill-tilting, seem almost designed to encourage misunderstanding (not for the first time: on a previous occasion he went so far as to write that the neo-Darwinian synthesis was 'effectively dead'!). The following is typical of the publicity surrounding Wonderful Life (incidentally, I suspect that the lead sentence was added without the knowledge of the credited journalist): "The human race did not result from the 'survival of the fittest', according to the eminent American professor, Stephen Jay Gould. It was a happy accident that created Mankind" (Daily Telegraph, 22nd January 1990). Such twaddle, of course, is nowhere to be found in Gould, but whether or not he seeks that kind of publicity he all too frequently attracts it. Readers regularly gain the impression that he is saying something far more radical and surprising than he actually is.

'Survival of the fittest' means individual survival, not survival of major lineages. Any orthodox Darwinian would be entirely happy with major extinctions being largely a matter of luck. Admittedly there is a minority of evolutionists who think that Darwinian selection chooses between higher-level groupings. They are the only Darwinians likely to be disconcerted by Gould's 'contingent extinction'. And who is the most prominent advocate of higher-level selection today? You've guessed it. Hoist again!

Richard Dawkins

A scientist's view
by Richard Dawkins
Article in The Guardian, Saturday March 9, 2002

The Rome-deniers, let's imagine, are a well-organised group of nutters, implacably convinced that the Roman empire never existed. The Latin language, for all its rich literature and its romance language grandchildren, is a Victorian fabrication.

The Rome-deniers are, no doubt, harmless wingnuts, more harmless than the Holocaust-deniers whom they resemble. Smile and be tolerant. But your tolerance might wear thin if you are a scholar and teacher of Roman history or literature.

And what if Rome-deniers manage to infiltrate the teaching staff of an otherwise reputable school, and energetically promote their inanities to a susceptible new generation? A normally tolerant person could be forgiven for wanting to see those teachers fired.

Well, that's approximately where I stand with respect to the clique of Genesis creationists who have moved in on Emmanuel College, Gateshead. What they deny is the unassailable evidence for biological evolution. The present head of the school, Nigel McQuoid, with his predecessor John Burn, wrote the following: "We agree that [schools] should teach evolution as a theory and faith position... Clearly also schools should teach the creation theory as literally depicted in Genesis. Both creation and evolution provide ways of explaining the past that are beyond direct scientific examination and verification. Ultimately, both creation and evolution are faith positions."

The vice-principal, head of science, senior assessment coordinator and maths teacher, have all said something similar.

Creation as literally depicted in Genesis is indeed supported by faith (and needs to be, since it is not supported by anything else, certainly not the Pope, nor the Roman or Anglican hierarchies). Evolution, on the other hand, is supported by evidence.

Any science teacher who denies that the world is billions (or even millions!) of years old is teaching children a preposterous, mind-shrinking falsehood. These men disgrace the honourable profession of teacher. By comparison, real teachers, teachers who respect truth and evidence whether in science or history, have so much more to offer. Today's children are blessed with the opportunity to open their minds to the shattering wonder of their own existence, the nature of life and its remarkable provenance in a yet more remarkable universe. Teachers who help to open young minds perform a duty which is as near sacred as I will admit. Ignorant, closed-minded, false teachers who stand in their way come as close as I can reckon to committing true sacrilege.

All Our Yesterdays

by Richard Dawkins

12/31/1995, The Times of London (Travel)

Evolutionist Richard Dawkins found heroes and inspiration for the future, too, when he returned to Kenya to search for his roots, our species' ancestors, and a well-loved childhood garden.

EARLIEST memories can build a private Eden, a lost garden to which there is no return. The name Mbagathi conjured up myths in my mind. Early in the war my father was called from the colonial service in Nyasaland (now Malawi) to join the army in Kenya. My mother disobeyed instructions to stay behind in Nyasaland and drove with him, along rutted dust roads and over unmarked and fortunately unpoliced borders, to Kenya, where I was later born and lived until I was two. My earliest memory is of the two whitewashed thatched huts that my parents built for us in a garden, near the small Mbagathi River with its footbridge where I once fell into the water. I have always dreamt of returning to the site of this unwitting baptism, not because there was anything remarkable about the place, but because my memory is void before it.

That garden with the two whitewashed huts was my infant Eden and the Mbagathi my personal river. But, on a larger timescale, Africa is Eden to us all, the ancestral garden whose Darwinian memories have been carved into our DNA over some 15m years until our recent worldwide Out of Africa diaspora. It was at least partly the search for roots, our species' ancestors and my own childhood garden, that took me back to Kenya last December.

My wife, Lalla, happened to sit next to Richard Leakey at a lunch to launch his The Origin of Humankind and by the end of the meal he had invited her (and me) to spend Christmas with his family in Kenya. Could there be a better beginning to a search for humanity's roots than a visit to the Leakey family on their home ground? We accepted gratefully. On the way, we spent a few days with an old colleague, the economic ecologist Dr Michael Norton-Griffiths and his wife, Annie, in their house at Langata, near Nairobi, which proved to be a paradise of bougainvillea and lush green gardens, marred only by the evident necessity for the Kenyan equivalent of the burglar alarm the armed askari, hired to patrol the garden at night by every householder who can afford the luxury.

I didn't know where to start in quest of my lost Mbagathi. I knew only that it was somewhere near greater Nairobi. That the city had expanded since 1943 was only too obvious. For all I could tell, my childhood garden might languish under a car park or an international hotel. At a neighbour's carol-singing party I cultivated the greyest and most wrinkled guests, seeking an old brain in which the name of Mrs Walter, the philanthropic owner of our garden, or that of Grazebrooks, her house, might have lodged. Though intrigued at my quest, none could help. Then I discovered that the stream below the Norton-Griffiths' garden was named the Mbagathi River. There was a steep red-soil track down the hill and I made a ritual pilgrimage. At the foot of the hill, not 200yd from where we were living, was a small footbridge and I stood and sentimentally watched the villagers returning home from work over the Mbagathi River.

I don't, and probably never shall know, if this was "my" bridge, but it probably was my river, for rivers outlive human works. I never discovered my garden and I doubt if it survives. Human memory is frail, our traditions as erratic as Chinese whispers and largely false; written records crumble and, in any case, writing is only millenniums old. If we want to follow our roots back through the millions of years, we need more persistent race memories. Two exist, fossils and DNA hardware and software. The fact that our species now has a hard history is largely to the credit of one family, the Leakeys: the late Louis Leakey, his wife Mary, their son Richard and his wife Maeve. It was to Richard and Maeve's holiday house at Lamu that we were going for Christmas.

The engagingly filthy town of Lamu, one of the strongholds of Islam bordering the Indian ocean, lies on a sandy island close to the mangrove fringes of the coast. The imposing waterfront recalls Evelyn Waugh's Matodi in the first chapter of Black Mischief. Open stone drains, grey with suds, line streets too narrow for wheeled traffic, and heavily laden donkeys purposefully trot their unsupervised errands across the town. Skeletal cats sleep in patches of sun, black-veiled women, like crows, walk obsequiously past gentlemen lording it on their front doorsteps, talking the heat and the flies away. Every four hours the muezzins (nowadays they are recorded on cassette tapes concealed in the minarets) caterwaul for custom. Nothing disturbs the marabou storks at their one-legged vigil round the abattoir.

We left the high plateau of Nairobi for the heat of Lamu in a creaking, wartime Dakota that had first seen service when I was crawling out of the Mbagathi River. The unpaved landing strip is across the water from Lamu, and Richard and Maeve Leakey met us in a small motorboat. We beached below their house some way from the town and their younger daughter Samira (an appropriately pretty Swahili name) waded out to help carry our luggage up the sand. At the veranda we dropped our shoes and rinsed our feet in stone troughs before mounting the steps.

There we met Samira's equally delightful sister, Louise, who is studying fossils at Bristol University, and the other guests of this hospitable family.

The Leakeys are white Kenyans, not English, and they built their house in the Swahili style (this is native Swahili country, unlike most of Kenya where the Swahili language is a lingua franca spread by the Arab slave trade). It is a large, white, thankfully cool cathedral of a house, with an arched veranda, tiles and rush matting on the floor, no glass in the windows, no hot water in the pipes and no need for either. The whole upstairs floor (reached by irregularly cut outside steps) is a single flat area furnished only with rush mats, cushions and mattresses, completely open to the warm night winds and the bats diving past Orion. Above this airy space, raised high on stilts, is the unique Swahili roof, thatched with reeds on a lofty superstructure of palm logs, intricately lashed together with thongs.

Richard Leakey is a robust hero of a man, who actually lives up to the cliche, "a big man in every sense of the word". Like other big men, he is loved by many, feared by some, and not over-preoccupied with the judgments of any. He lost both legs in a near-fatal air crash in 1994, at the end of his rampantly successful years crusading against poachers. As director of the Kenya Wildlife Service, he transformed the previously demoralised rangers into a crack fighting army with modern weapons to match those of the poachers and, more importantly, with an esprit de corps and a will to hit back at them. In 1989 he persuaded President Moi to light a bonfire of more than 2,000 seized tusks, a uniquely Leakeyan masterstroke of public relations that did much to destroy the ivory trade and save the elephant. But jealousies were aroused by his international prestige, which helped raise funds for his department money that other officials coveted. Hardest to forgive, he conspicuously proved it possible to run a big department in Kenya efficiently and without corruption. Leakey had to go, and he did. Coincidentally, his plane had unexplained engine failure and now he swings along on two artificial legs (with a spare pair with flippers specially made for swimmings). He again races his sailing boat with his wife and daughters for crew, he lost no time in regaining his pilot's licence, and his spirit will not be crushed. If Richard Leakey is a hero, he is matched in elephant lore by that legendary and redoubtable couple Iain and Oria Douglas-Hamilton. Iain and I had been students of the great naturalist Niko Tinbergen at Oxford, as had Mike Norton-Griffiths. It was a long time since we had met, and the Douglas-Hamiltons invited Lalla and me to Lake Naivasha for the final part of our holiday. He is the son of a dynasty of warlike Scottish lairds and, more recently, ace aviators; she, the daughter of equally swashbuckling Italian-French adventurers in Africa. Iain and Oria met romantically and lived dangerously. They know wild elephants better than anyone and raised their baby daughters to play fearlessly among them. They fought the ivory trade with words and the poachers with guns.

Oria's parents, explorers and elephant hunters in the 1930s, built Sirocco, the "pink palace", a stunning monument to art-deco stylishness on the shores of Lake Naivasha, where they settled to farm 3,000 acres. When they died, the place fell into disrepair for 10 years, until a determined Oria, against all economic advice, returned. The farm, though no longer 3,000 acres, now thrives again, at immense cost in hard work. Not content with this load, Oria has founded a family planning clinic for thousands of working women from the surrounding area. She takes paying guests (mostly small groups or honeymooners seeking and finding their own Garden of Eden) in Olerai, an idyllic smaller house, whitewashed, covered with flowers and set amid yellow fever trees, separated from Sirocco by the magnificent jacaranda avenue. Iain flies his tiny plane home every weekend from Nairobi, where he runs his newly formed charity, Save the Elephants. The family were all at Sirocco for Christmas and we were to join them for New Year.

Our arrival was unforgettable: music was thumping through open doors (Vangelis's score for 1492 I later chose it for Desert Island Discs), and the assembled company of 20 guests was about to sit down to a characteristic lunch of lake crayfish risotto. We looked out over the terrace at the small paddock where, 25 years before, uninvited and unexpected, Iain had landed his plane to the terrified incredulity of Oria's parents and their guests at a similarly grand luncheon party. At dawn the morning after this sensational entrance into her life, Oria had, without hesitation, taken off with Iain for the shores of Lake Manyara, where the young man had begun his now famous study of wild elephants, and they have been together ever since. Their story is told in their two books, the idyllic Among the Elephants and the more sombre Battle for the Elephants.

Lalla and I both fell in love with the Douglas-Hamilton daughters, Saba and Dudu, now grown up. Wild elephants must make wonderful nursery companions for young humans. On the veranda, staring towards Mount Longonot, is the skull of Boadicea, giant matriarch of Manyara, mother or grandmother of so many of Iain's study animals, victim of the poaching holocaust, her skull devotedly strapped into the back seat of Iain's plane and flown to its final rest, overlooking a peaceful garden.

Every night during our stay at Naivasha, Iain led out a party with torches to spot the hippos rumbling and grunting up from the lake to graze the garden (and, on one occasion before we arrived, fall into the swimming pool). Our time at Naivasha was paradise. The only false note in its music was an ugly rumour that a leopard had been snared on a neighbouring farm and was painfully dragging the snare somewhere in the area. Grown quiet with anger, Iain took down his gun, called for the best Masai tracker on Oria's farm, and we set off in an ancient Land Rover.

The plan was to find the leopard by tracking and by questioning witnesses, lure it into a trap, nurse it back to health and release it again on the farm. Knowing no Swahili, I could gauge the progress of Iain's cross-examinations only by facial expressions, tones of voice, and his occasional summaries for my benefit. We eventually found a young man who had seen the leopard, though he denied it at first. Iain whispered to me that such initial denials baffling to my naive straightforwardness were ritual and normal. Eventually, without for a moment acknowledging that he had changed his story, the youth would lead us to the scene. Sure enough he did, and there the Masai tracker spotted leopard hairs and a possible spoor. He bounded, doubled up, through the papyrus reeds, followed by Iain and me. Just when I thought we were hopelessly lost, we re-emerged at our starting point. The trail had gone cold.

By similarly roundabout verbal skirmishings we tracked down a more recent witness, who led us to another clearing in the papyrus, and Iain decided that here was the best site for a trap. He telephoned the Kenya Wildlife Service and they came, within the day, with a large iron cage filling the back of a Land Rover. Its door was designed to clang shut when the bait of meat was tugged. At dead of night we lurched and bumped through the papyrus and hippo dung, camouflaged the trap with foliage, laid a trail of raw meat to its entrance, baited it with half a sheep and went to bed.

The next day, Lalla and I were due to return to Nairobi and we left with the trap still baited, having attracted nothing more substantial than a marsh mongoose. Iain flew us in his little plane, hopping over steaming volcanic hills and down lake-filled valleys, over zebras and (almost under) giraffes, scattering the dust and the goats of the Masai villages, past the hilltop graves of Diana Delves-Broughton and most of the characters in White Mischief, skirting the Ngong hills to Nairobi. We buzzed the ever generous Norton-Griffiths in Langata as the signal to them to meet us at Wilson airport, where we also chanced to run into Maeve Leakey. She has now largely taken over the running of the fossil-hunting work from Richard, and she offered to introduce us to our ancestors in the vaults of the Kenya National Museum. This rare privilege was arranged for the next day, the morning of our departure for London.

The great archeologist Schliemann "gazed upon the face of Agamemnon". Well, good, the mask of a Bronze Age chieftain is a fine thing to behold. But as Maeve Leakey's guest I have gazed upon the face of KNM-ER 1470 (Homo habilis) who lived and died 20,000 centuries before the Bronze Age began. Each fossil is accompanied by a meticulously accurate cast that you are allowed to hold and turn over as you look at the priceless original. The Leakeys told us that their team was opening up a new site at Lake Turkana, with fossils 4m years old, older than any hominids so far discovered. In the week that I write this, Maeve and her colleagues have published in Nature the first harvest of this ancient stratum: a newly discovered species, Australopithecus amartensis, represented by a lower jaw and various other fragments. The new finds suggest that our ancestors were already walking upright 4m years ago, surprisingly close (to some) to our split from the lineage of chimpanzees. Since we left Kenya, Richard Leakey has founded a new political party, dedicated to destroying corruption in Kenyan public life. He and his party have been subjected to a sustained campaign of vilification and verbal attacks. He has been accused of everything under the sun including colonialism, "atheism" as though it were a crime and, absurdly, "racism". Apart from being famously incorruptible and unracist, this third-generation Kenyan's unique appeal in his country's politics is his conspicuous immunity from the tribalism that is Africa's dominant form of racism. Recently he was dragged out of his car a man with no legs and only one (donated) kidney, a scholar and scientist of international distinction and savagely whipped on his back and shoulders. Lalla telephoned him when we read the news (in a tiny inside-page paragraph, for the outrage was strangely under-reported in Britain) and found him insouciant as one has come to expect. Not a well-chosen candidate for political intimidation. The leopard, Iain later told us, never came to the trap. He had feared that it would not, for the evidence of the second witness suggested that, fatally hobbled by the snare, it was already near death from starvation. For me, the most memorable part of that leopard-tracking day was my conversation with the two black rangers from the Kenya Wildlife Service who brought the trap. I was deeply impressed by the efficiency, humanity and dedication of these men. They were not allowed to let me photograph their operation, and they seemed a little reserved until I mentioned the name of Dr Leakey, their former leader, now in the political wilderness. Their eyes immediately lit up. "Oh, you know Richard Leakey? What a wonderful man, a magnificent man!" I asked them how the Kenya Wildlife Service was faring nowadays. "Oh well, we soldier on. We do our best. But it is not the same. What a magnificent man!"

We went to Kenya to find the past. We found heroes and inspiration for the future, too.

TRAVEL BRIEF Getting there: British Airways (0345-222111), Air France (0181-742 6600), Kenya Airways (0171-409 0277) and KLM (0181-750 9000) all fly scheduled services to Nairobi; fares from about Pounds 900 in January. Several consolidators including Trailfinders (0171-938 3366) and Travel Bug (0990-737747) have a special fare of Pounds 299 on Air France from January 11 to the end of March, travel must be on Thursdays. Air Kenya (00 254 2-501421) flies daily from Nairobi to Manda island, the nearest airport for Lamu, prices about $112 (Pounds 73) each way. Health precautions: consult your GP before travel for the necessary vaccinations. You will need to take antimalarial tablets. Tour operators include: Abercrombie & Kent (0171-730 9600), Bales Tours (01306-885991), Elite Vacations (0181-864 4431), Kuoni (01306-740500), Somak Holidays (0181-423 3000), Thomson (0171-707 9000) and Worldwide Journeys & Expeditions (0171-381 8638). For a complete list of operators call the Kenyan Tourism Office. If you would like to stay at the Douglas-Hamiltons' home, Olerai, rates are from $180 (Pounds 117) per person per day. For further details, call 00 254 2-334868 or fax 332106. Further information: Kenya Tourism Office on 0171-355 3144.

An early flowering of genetics

This is an edited version of Richard Dawkins' introduction to a new edition of Charles Darwin's The Descent of Man, published by Gibson Square Books, price £10. This piece also appears in A Devil's Chaplain: Selected Essays by Richard Dawkins, published by Weidenfeld next week, price £16.99
Article in The Guardian Review Saturday February 8, 2003
Charles Darwin's theory of human evolution was published long before knowledge of genes was available. But Richard Dawkins reveals that an obscure letter found in a library proves Darwin was already doing research into heredity which anticipated the breakthroughs of the next century

Humanity is the missing guest at the feast of Charles Darwin's Origin of Species, published in 1859. The famous "light will be thrown on the origin of man and his history" is a calculated understatement matched, in the annals of science, only by Watson and Crick's "it has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material".

By the time Darwin finally got around to throwing that light with the publication of The Descent of Man in 1871, others had been there before him and the greater part of his book is not about humans but about Darwin's "other" theory, sexual selection. It might have seemed a good idea to separate it into two books: Sexual Selection followed by the Descent of Man. But Darwin knew what he was doing.

The distinguished American philosopher Daniel Dennett has credited Darwin with the greatest idea ever to occur to a human mind. This was natural selection, the survival of the fittest, of course, and I would include sexual selection as part of the same idea. But Darwin was not only a deep thinker, he was a naturalist of encyclopaedic knowledge and (which by no means necessarily follows) the ability to hold it in his head and deploy it in constructive directions.

He was a master encyclopaedist, who collated huge quantities of information and observations solicited from naturalists all around the world, each gentleman meticulously acknowledged for having "attended to" the subject and sometimes complimented as a "reliable observer". I find an addictive fascination in his Victorian prose style, quite apart from the feeling one gets of having been ushered into the presence of one of the great minds of all time.

Prescient as he was (Michael Ghiselin, author of The Triumph of the Darwinian Method, University of Chicago Press, has said that he worked at least a century ahead of his time) Darwin was still a Victorian, and his book must be read in the context of its age, warts and all. What will grate most irksomely on the modern ear is the unquestioned Victorian presumption that animals in general, and humans in particular, are disposed on a ladder of increasing superiority.

Like all Victorians, Darwin happily referred to particular species as "lowly in the scale of nature". Even some modern biologists do this, though they should not, for all living species are cousins who have been evolving for exactly the same length of time since the common ancestor. What educated moderns never do, but equivalent Victorians always did, is think of human races in the same hierarchical way. It requires a special effort for us to read something like the following without distaste: "It seems at first sight a monstrous supposition that the jet blackness of the negro has been gained through sexual selection [ie, is attractive to the opposite sex]..."

But it is a mark of historical infantilism to view the writings of one century through the politically tinted glasses of another. The very title, The Descent of Man, will raise hackles among those naively locked into the mores of our own time. It can be argued that reading historic documents that violate the taboos of one's own century gives valuable lessons in the ephemerality of such mores. Who knows how our descendants will judge us?

Less obvious, but as important to understand, are the changes in the scientific climate. In particular, it is hard to overstate the fact that Darwin's genetics were pre-Mendelian (Gregor Mendel, 1822-84, did not live to see himself revered as the father of genetics). The intuitively plausible blending inheritance theory, that variation disappears over generations, of Darwin's time was not just wrong, it was grievously wrong and especially grievous for natural selection.

The fact that Darwinism could not work under the assumption of blending inheritance was pointed out in a hostile review of the Origin by the Scottish engineer Fleeming Jenkin. Variation tends to disappear with every blending generation, leaving not enough for natural selection to get its teeth into.

What Jenkin should have realised is that blending inheritance is incompatible not just with Darwinian theory but with obvious fact. If it were really true that variation disappeared, every generation should be more uniform than the previous one. By now, all individuals should be as indistinguishable as clones. Darwin needed only to retort to Jenkin: whatever the reason, it is obviously the case that there is plenty of inherited variation and that's good enough for my purposes.

It is often claimed that the answer to the riddle of the allegedly disappearing variation lay on Darwin's shelves, in the uncut pages of the proceedings of the Brunn Natural History Society where nestled Mendel's paper on "Versuche über Pflanzen-Hybriden". Unfortunately this poignant story seems to be an urban myth. The two scholars best placed (at Cambridge and at Down House) to know what was in Darwin's personal library can find no evidence that he ever subscribed to the proceedings, nor does it seem likely that he would have done so. They have no idea where the legend of the "uncut pages" originated.

Once originated, however, it is easy to see that its very poignancy might speed its proliferation. The whole affair would make a nice little project in memetic research [the theory, outlined in The Selfish Gene, that ideas are "viral"] complementing that other popular urban legend, the agreeable falsehood that Darwin turned down an offer from Marx to dedicate Das Kapital to him.

Mendel did indeed have exactly the insight Darwin needed. Its relationship to the Jenkin critique, however, would not have been immediately obvious to the Victorian mind. Even after Mendel's work was rediscovered in 1900, it was not until RA Fisher, founder of modern statistics and of British population genetics, came along in 1930 that its supreme relevance to Darwinism was widely understood. If heredity is particulate - if, as Mendel showed, a gene is an individisible entity such that you either have it or you don't, with no half measures - variation does not disappear but is reconstituted in every generation. Neo-Darwinian evolution precisely means change in gene frequencies in gene pools.

What is genuinely poignant is that Darwin himself came tantalisingly close to Mendel's conclusion. Fisher quotes him in a letter to Huxley of 1857: "I have lately been inclined to speculate, very crudely and indistinctly, that propagation by true fertilisation will turn out to be a sort of mixture, and not true fusion, of two distinct individuals, or rather of innumerable individuals, as each parent has its parents and ancestors. I can understand on no other view the way in which crossed forms go back to so large an extent to ancestral forms. But all this, of course, is infinitely crude."

Fisher cleverly remarked that Mendelism has a kind of necessary plausibility, which could have led to its discovery by any thinker in a mid-Victorian armchair. He might have added that particulate inheritance stares us in the face whenever we contemplate sex itself (as we not infrequently do). All of us have one female and one male parent, yet each of us is either male or female, not an intermediate hermaphrodite. Fascinatingly, Darwin himself made this very point, clearly, in an 1866 letter to fellow naturalist Alfred Wallace, which Fisher would surely have quoted had he known of it.

"My dear Wallace... I do not think you understand what I mean by the non-blending of certain varieties. It does not refer to fertility; an instance will explain. I crossed the Painted Lady and Purple sweetpeas, which are very differently coloured varieties, and got, even out of the same pod, both varieties perfect but none intermediate. Something of this kind I should think must occur at least with your butterflies & the three forms of Lythrum; tho' these cases are in appearance so wonderful, I do not know that they are really more so than every female in the world producing distinct male and female offspring...

Believe me, yours very sincerely Ch. Darwin"

Here Darwin comes closer to anticipating Mendel than in the passage quoted by Fisher, and he even mentions his own Mendel-like experiments on sweet peas. I am extremely grateful to Dr Seymour J Garte of New York University, who found this letter by chance in a volume of correspondence between Darwin and Wallace in the British Library in London, immediately recognised its significance and sent a copy to me.

Another piece of Darwin's unfinished business later sorted out by Fisher was the matter of the sex ratio, and how it evolves under natural selection. Fisher begins by quoting the second edition of The Descent of Man, in which Darwin prudently said: "I formerly thought that when a tendency to produce the two sexes in equal numbers was advantageous to the species, it would follow from natural selection, but I now see that the whole problem is so intricate that it is safer to leave its solution to the future."

Fisher's own solution made no appeal to species advantage. Instead he pointed out that, since every individual born has one father and one mother, the total male contribution to posterity must equal the total female contribution. If the sex ratio is anything other than 50/50, therefore, an individual of the minority sex can expect, other things being equal, a greater share of descendants, and this will set up selection in favour of rebalancing the sex ratio.

Fisher rightly used economic language to express the strategic decisions involved: they are decisions over how to allocate parental expenditure. Natural selection will favour parents who spend proportionately more food or other resources on offspring of the minority sex. Such correcting selection will continue until the total expenditure on sons in the population balances the total expenditure on daughters. This will amount to equal numbers of males and females, except in those cases where offspring of one sex cost more to rear than offspring of the other.

If, for example, it costs twice as much food to rear a son than a daughter (perhaps to make sons big enough to compete effectively with rival males) the stable sex ratio will be twice as many females as males. This is because the strategic alternative to one son is not one daughter but two. Fisher's powerful logic has been extended and refined in various ways, for example by WD Hamilton and EL Charnov.

Once again, and notwithstanding the quotation above from the second edition, Darwin himself, in the first edition, came remarkably close to anticipating Fisher, although without the economic language of parental expenditure:

"Let us now take the case of a species producing, from the unknown causes just alluded to, an excess of one sex - we will say of males - these being superfluous and useless, or nearly useless. Could the sexes be equalised through natural selection? We may feel sure, from all characters being variable, that certain pairs would produce a somewhat less excess of males over females than other pairs. The former, supposing the actual number of the offspring to remain constant, would necessarily produce more females, and would therefore be more productive. On the doctrine of chances, a greater number of the offspring of the more productive pairs would survive; and these would inherit a tendency to procreate fewer males and more females. Thus a tendency toward equalisation of the sexes would be brought about."

Sadly, Darwin deleted this remarkable passage when he came to prepare the second edition, preferring the more cautious paragraph later to be quoted by Fisher. Darwin's partial anticipation of Fisher in the first edition of Descent is all the more impressive because, as my colleague Alan Grafen points out to me, Fisher's argument depends crucially on a fact that was not available to Darwin, namely that the two parents make an equal genetic contribution to every offspring. Indeed, in historical times, different schools of thought (the spermists and the ovists respectively) had held that the male, or the female, sex had a monopoly on heredity.

Now, to the descent of man itself. Darwin's guess that our species arose in Africa was typically ahead of his time, amply confirmed today by numerous fossils, none of which was available to him. We are African apes, closer cousins to chimpanzees and gorillas than they are to orang-utans and gibbons, let alone monkeys.

Darwin's "quadrumana" were defined so as to exclude humans: they were all the apes and monkeys, with a hand bearing an opposable digit on the hindlegs as well as the forelegs. The early chapters of his book are concerned to narrow the perceived gap between ourselves and the quadrumana, a gap that Darwin's target audience would have seen as yawning between the top rung of a ladder and the next rung down. Today we would not (or should not) see a ladder at all. Instead, we should hold in our minds the branching tree diagram, which is the only illustration in The Origin of Species. Humanity is just one little twig, nestling among many others somewhere in the middle of a thicket of African apes.

Darwin went to town on sexual selection in The Descent of Man because he thought it was important in human evolution, and especially because he thought it was the key to understanding the differences among human races. The topic is prominent in Darwin's book and especially germane to the unification of its two parts.

Darwin, like all Victorians, was intensely aware of the differences among humans but he also, more than most of his contemporaries, emphasised the fundamental unity of our species. In Descent he carefully considered, and decisively rejected, the idea, rather favoured in his own time, that different human races should be regarded as separate species.

Today we know that, at the genetic level, our species is more than usually uniform. It has been said that there is more genetic variation among the chimpanzees of a small region of Africa than among the entire world population of humans (suggesting that we have been through a bottleneck in the past 100,000 years or so). Moreover, the great majority of human genetic variation is to be found within races, not between them. This means that if you were to wipe out all human races except one, the great majority of human genetic variance would be preserved. The variance between races is just a bit extra, stuck on the top of the greater quantity of variation within all races. It is for this reason that many geneticists advocate the complete abandonment of the concept of race.

At the same time - the paradox is similar to one recognised by Darwin - the superficially conspicuous features characteristic of local populations around the world seem very different. Why did such pronounced superficial differences evolve in different geographical areas, while most of the less conspicuous variation is dotted around across all geographical areas? Could Darwin have been right all along? Is sexual selection the answer to the paradox? The distinguished biologist Jared Diamond thinks so, and I am inclined to agree.

What sexual selection explains, better than natural selection, is diversity that seems arbitrary, even driven by aesthetic whim. Especially if the variation concerned is geographical. And also especially if some of the features concerned, for example beards and the distribution of body hair and subcutaneous fat deposits, differ between the sexes.

Most people have no problem in accepting an analogue of sexual selection for culturally mediated fashions like headdresses, body paint, penis sheaths, ritual mutilations or ornamental clothes. Given that cultural differences such as those of language, religion, manners and customs certainly provide resistance to interbreeding and gene flow, I think it is entirely plausible that genetic differences between peoples of different regions, at least where superficial, externally prominent features are concerned, have evolved through sexual selection.

Our species really does seem to have unusually conspicuous, even ostentatious, superficial differences between local populations, coupled with unusually low levels of overall genetic variation. This double circumstance carries, to my mind, the stamp of sexual selection.

In this, as in so much else, I suspect that Darwin was right. Sexual selection really is a good candidate for explaining a great deal about the unique evolution of our species. It may also be responsible for some unique features of our species that are shared equally by all races, for example our enormous brain. It is starting to look as though, despite initial appearances, Darwin really was right to bring together, in one volume, Selection in Relation to Sex and the Descent of Man.

 This is an edited version of Richard Dawkins' introduction to a new edition of Charles Darwin's The Descent of Man, published by Gibson Square Books, price £10. This piece also appears in A Devil's Chaplain: Selected Essays by Richard Dawkins, published by Weidenfeld next week, price £16.99

An eclipse, It's my kind of magic

An eclipse? It's my kind of magic, - "A solar eclipse has an undeniable aura, but stripping away all its mystical baggage, says Richard Dawkins, reveals the true magic - science, The Sunday Times, July 25, 1999

The total solar eclipse on August 11, when the moon's shadow will cross the Atlantic in a swift half-hour, making landfall in Cornwall at 11:11 am, is the first to hit mainland Britain since 1927. We won't have another until September 23, 2090. The 1927 eclipse gave Yorkshire 15 seconds of totality, compared with the two minutes that south Cornwall will enjoy this year. Even so, about 3m people, Virginia Woolfs Bloomsbury party among them flocked north to witness it in what is believed to be the largest single movement of people by train.

I have never seen a total solar eclipse and 1 don't intend to miss this one. Our family were going to Cornwall, but we changed our minds when we heard about the druids, astrologers and new age airheads who threaten to overrun that unfortunate county. The Archdruid of Cornwall, claiming that “there is not a lane in Cornwall where someone hasn't seen fairies or the little people", is planning a god and goddess night, evenings of fortune-telling and a sun dance to discourage rain on the day of the eclipse.

So it's Austria for us, a little farther along the shadow's path, where there should be less "spirituality" to distract from the real magic of the eclipse.

Why has such an aura of mystery grown up around total solar eclipses? It's partly that they are perceived as rare. But they are not rare, if we take the planet as a whole. It's just that the long narrow area swept out by each path of totality is small compared with the area of the planet, most of which is uninhabited.

More years than not, there is a total eclipse of the sun to be seen somewhere on Earth. The town of Novo Rodondo in Angola will have one on June 21, 2001, and another on December 4, 2002. There's a spot in the Pacific - for all 1 know there's an inhabited island there - which will experience total solar eclipses in 2005. 2010 and 2019, and will be very close to a fourth in 2020. Dedicated eclipse groupies who are prepared to travel, the world in pursuit of them will have 68 solar eclipses to choose from in the next century'.

Incidentally, the apparent rarity but actual commonness of eclipses makes them handy for astrologers. Someone has sent me an analysis of Prince Charles and Princess Diana’s lives (amusingly, its feats of divination were retrospective) showing that each significant event occurred within a year or so of an eclipse. But eclipses are so frequent that the key events in any life can't help being associated with an eclipse somewhere in the world. The best one is Prince William's birth, which occurred on the same day as a partial eclipse - in Antarctica.

If we must make portents out of eclipses, Northern Ireland will experience its next total eclipse of the sun on June 14, 2151. Not quite the anniversary of the battle of the Boyne, but June 14 is the very day William of Orange first landed in Ulster on his campaign which culminated at the Boyne, symbol of the religious hatreds that beset the unhappy province. Perhaps the largeness of this astronomical prodigy will help to shrink Bigendian versus Littlendian bickerings into proportion. Might we even dare to hope that, by 2151, there won't be any Catholics or Protestants left, only people?

What is it about a total eclipse of the sun that leads many, to describe it as the most amazing experience of their lives? We are able to see (and conduct normally, impossible research on) the suns glowing, Corona and if we are very lucky, solar flares; also jewel like Baily’s beads which are profiles of mountain valleys on the moon.

Reports also speak of an eerie quiet as bewildered birds stop singing (though in a another report the quiet was shattered by people “hooting and hollering like pagans”). It may feel menacingly colder and some feel a yearning sensation of loss, followed by exultation when the light returns. All this I can only look forward to, having no personal experience.

Virginia Woolf wrote in her diary in 1927: “I had very strongly the feeling as the light went out of some vast obeisance; something kneeling down and suddenly raised up when the colours came. They came back astonishingly quickly and beautifully in the valley and over the hills - at first with a miraculous glittering and ethereality, later normally almost, but with a great sense of relief. It was like recovery ... We had seen the world dead.”

From a high vantage point in clear dry climates you may watch the shadow hurtling apocalyptically across the plains at 1.000mph. This must he a spellbinding sight. Here's another, and this you can experience in regions where the eclipse is not total, including the whole of Britain on August 11 (always assuming the weather is fine). Before the eclipse, find a wood where sunlight filters through the canopy. Notice how many of the dappling patterns on the ground are near-perfect circles. The reason is not that the canopy has circular holes for the sun to shine through. Regardless of shape, each small gap between the leaves acts as the pinhole of a natural pinhole camera. Each circular spot on the forest floor is an inverted real image of the round sun. Now, imagine what will happen to those hundreds of little sun images during a partial eclipse, when the sun becomes a slender crescent. You can keep your fairies and little people. Here is authentic magic on the forest floor.

Any object in the solar system, whether planet, moon or asteroid offers a shadow on the side away, from the sun. 'Me shadows usually fall on empty space. But because the solar system originally condensed out of a spinning disc of gas, most of its orbiting bodies are still confined to one disc-shaped plane. The sun is the centre of the disc, so planets and moons shade each other more often than they would if they formed a spherical cloud around the sun. We don’t notice when Venus or Mercury traverses the sun, but the moon is another matter because it is so close. Being part of the primordial disc, it orbits the Earth in roughly the same plane as the Earth orbits the sun so, not surprisingly, its shadow sometimes falls on the Earth (eclipse of the sun) and the Earth's shadow sometimes falls on the moon (eclipse of the moon).

If the two orbits were exactly in the same plane - if the solar system were the perfect remains of a perfect disc - why, then, eclipses would have to occur every month of every year. The moon would be eclipsed whenever it was full (opposite the sun from Earth). Two weeks later, the new moon (between the sun and us) would inevitably eclipse the sun. But reality is messier than my idealised abstraction. The moon orbits the Earth in its own little plane, which is tilted at about five degrees to the Earth's orbit around the sun. As these two tilted orbits move in and out of phase with each other, the monthly opportunities for a solar eclipse are actually taken up only occasionally, according to a complicated pattern called the saros cycle which repeats itself every 18 years.

In most months, at new moon when there should ideally be an eclipse of the sun, the shadow of the moon misses the Earth altogether. In effect it passes north of the North Pole or south of the South Pole. The saros cycle takes no account of the spinning of the Earth on its independently tilted axis so—another complication—the 18 year repeats don’t revisit the same part of the world.

Because the Earth spins on its own axis every 24 hours, an eclipse shadow sweeps very fast along a roughly eastward path, thousands of miles long but very narrow. Only people in this path see a total eclipse. Many more people, in a much wider band, see a partial eclipse with part of the sun's disc obscured and a crescent remaining.

In any one spot, a total eclipse lasts only a matter of minutes as the shadow speeds over the surface of the globe. But in the same spot we can see the sun partially eclipsed for an hour or so as its crescent shrinks towards totality, and for another hour or so after totality as the opposite crescent grows towards the full sun.

The diameter of the sun is about 400 times that of the moon. And, as it happens the sun is about 400 times farther away from us than the moon. So the moon fits almost exactly over the sun. The coincidence is pure luck, completely meaningless, though many prefer to credit providence.

Anyway, it has a satisfying consequence. If the moon’s apparent size were larger. We shouldn't see the sun's corona, solar flares or Baily’s beads: an eclipse would be just like ordinary night. If the moon's apparent diameter were less than the sun's ... well, that happens sometimes and we see an "annular" eclipse: a ring of bright sun all round the moon’s circumference. It happens because the moon's and the sun's distance from us are not fixed. When the moon is a bit farther away than usual compared with the sun, total eclipses become annular eclipses. The northern tip of Scotland will see one in 2003.

The coming eclipse may conjure for us the shade of Einstein. General relativity momentously predicted that light from distant stars should he bent by, the mass of the sun and the apparent position of the stars should shift. But the effect would be big enough to detect only if the light beams passed very close to the sun. Stars appearing that close to the sun can't be seen against its glare. Except…during a total eclipse. So, Arthur Eddington took his instruments to Principe Island for the eclipse of 1919 and returned in triumph. Einstein himself was underwhelmed. If the predictions had not been fulfilled he would have been "sorry for the dear Lord. The theory is correct".

Most of all, what 1 appreciate about eclipses is the scalpel-sharp precision with which they can be predicted. In 19th-century boys' yarns, Rider Haggard's heroes would use an exactly forecast eclipse to confound (literally) benighted savages. For me, that same precision stands for the power of science to confound today's metaphorically benighted intellectual savages who fashionably deny that there is a real world or that we can discover true facts about it. As Dr Johnson said: " I refute it thus."

Article in The Daily Telegraph March 18, 2002

THE absurd row over Emmanuel City Technology College in Gateshead has raised an even more absurd confusion, which must be cleared up.

There are not two debating positions, but three. Actually more than three, and some of them could be represented as a shaded continuum, but for simplicity I'll stick to three.

1) Young Earth Creationists. They believe the world is only thousands of years old, based on a literal reading of Genesis (or the Koran, or whatever is their holy book).

2) Old Earth Theists. Theirs is a broad church, embracing the great majority of educated religious people. They believe in a Divine Creator, but they read their creation myth allegorically rather than literally, and accept that the world is billions of years old.

With the exception of some Old Earth Creationists, they mostly agree that evolution happened, but may allow God some supervisory role. Many think evolution was God's ingenious way of accomplishing his creation. Some believe he helped evolution over the difficult jumps.

Others think God kept his hands off evolution, but set up the universe in the first place in such a way as to make it likely to happen.

3) Atheists and agnostics.

Within the broad middle group, you'll find the Pope, the Archbishop of Canterbury, the Bishop of Oxford (who gave an admirable Thought for the Day on the subject on Friday) and, I would guess, most of the bishops and clergy of the Roman and Anglican churches.

You'll also find Tony Blair and those of his parliamentary colleagues of all parties who profess religious belief. You will not find the head of science at Emmanuel CTC, Gateshead.

I count myself in the third group, but it is not in that capacity that I object to what is happening in Gateshead. From time to time, I argue against Old Earth Theists, but not on this occasion.

On the Gateshead issue, scientists and theologians, bishops and atheists stand shoulder to shoulder. Young Earth teachers may do some damage to science education, but it's a pinprick compared with the damage they'll do to religious education if they get a grip on this side of the Atlantic.

Confusion is rife because commentators have failed to understand that the Gateshead row is about Young Earth Creationism. Wrongly presuming that we who have asked Ofsted for a re-inspection are attacking religion, they have rushed intemperately into print, not least in this newspaper, imputing to us all sorts of horrific Torquemadan motives.

Without bothering to read what we have said, and - worse - without bothering to read what the Gateshead teachers have said, they have assumed that we are attacking the middle group of mainstream religious believers.

As one retired contributor to The Daily Telegraph (letters, Mar 16) said: "I am a Christian and a scientist. I see no particular problem in reconciling the evolutionary and Creationist approaches to the formation of the Earth."

Well of course you don't see a problem, sir! You are a member of the large consensus in the middle. But the whole point of the Gateshead row is that the head of science at the school does see a problem. He is a Young Earth Creationist.

In the same issue of this newspaper, Tom Utley ("God knows what Professor Dawkins is talking about") tells me at insulting length what I already knew, namely that many Creationists don't think the earth is young. Why, Utley ponderously wonders, do I assume that the Gateshead teachers do?

For one excellent reason. I take the trouble to read what they say. Steven Layfield, the head of science at Emmanuel, gave a lecture on September 21, 2000 (which would therefore have been available to the Ofsted inspectors).

The full text is at: http://www.christian.org.uk/html-publications/education3.htm. Read it. If you love true science, or if you love true religion, the thought of what the children must be missing under this travesty of teaching may sadden you enough to provoke a letter to the Secretary of State for Education, urging her to reopen the case with Ofsted.

Layfield remarks that there is no immediate hope of evolution being removed from the national curriculum, and he lists ways in which Creationist science teachers can compensate.

For example: "Note every occasion when an evolutionary/old-earth paradigm (millions or billions of years) is explicitly mentioned or implied by a text-book, examination question or visitor, and courteously point out the fallibility of the statement. Wherever possible, we must give the alternative (always better) Biblical explanation of the same data."

For Layfield, then, the universe is not billions, not even millions, of years old. It is only thousands.

This head of science - this science teacher and mentor of other science teachers - blinds himself to the whole edifice of exciting scientific work, not just in biology and geology (fossils, the molecular clock, the geographic distribution of species in the light of plate-tectonic continental movements), but also physics (numerous independent methods of radioactive dating converge on the same answer) and cosmology (in a young universe, all stars would be invisible to us except the tiny minority within a few thousand light years).

Moving on in the lecture: "In view of the current inclusion of earth science into the Sc3 component of the national curriculum, it would seem particularly prudent for all who deliver this aspect of the course to familiarise themselves with Flood geology papers of Whitcomb & Morris . . .

"In particular, they would do well to point out that no rock is unearthed with a clear age label and that dating processes in general are speculative, frequently contradictory and in many instances altogether incompatible with a great age."

Yes, Flood geology means what you think it means. We're talking Noah's Ark here. Noah's Ark - when the children could be learning the spine-tingling fact that Africa and South America were once joined, and have drawn apart at the speed with which fingernails grow.

We have here the head of science, in a school that has received star rating from Ofsted. When I suggested a re-inspection, it had not occurred to me that the people who really come out of the affair badly are the Ofsted inspectors. It is not too late for them to make amends and look properly at what they obviously overlooked before.

With hindsight, it might have been better if those of us in Group Three had kept our big mouths shut and left it to the bishops. They have more to lose than we have, and are less vulnerable to prejudiced and perverse misunderstanding.

Over to you, gentlemen. Power to your elbows. If there is anything I can do to help, you'll find me lying low, with my head down. With the best will in the world, I seem to do more harm than good. It's somebody else's turn.

*   Richard Dawkins FRS is Oxford's Charles Simonyi Professor of the Public Understanding of Science. His latest book is Unweaving the Rainbow

Article in The Guardian December 27, 2001

This has been the year the human genome was announced, all but a few last details. As an achievement, it ranks with putting a man on the moon. Both are triumphs of the human spirit, like climbing Everest ("Because it is there") but more so because each is the cooperative culmination of millions of person hours of highly skilled work, brilliantly conceived, intricately organised, drawing upon the accumulated science of centuries. The human genome is a mountain climbed, not by a couple of individuals but by the human intellect itself. We can all be proud of our species as it closes in on this summit of self-knowledge.

Such projects are expensive, but worth it. They are examples of what we do when we live, rather than just work to stay alive. But they also contribute, in no mean strength, to the utilitarian business of staying alive.

The medical benefits of the genome project will become increasingly evident during our (consequently extended) lifetimes. Over the half century since Watson and Crick's discovery, the number of DNA codons that can be sequenced per unit-cost (allowing for inflation) has increased exponentially, with a doubling time of about 27 months. If the trend continues, a doctor in 2050 will be able to call up, for the price of a chest X-ray, a genome printout for each individual patient. She will then prescribe not an average dose but the tailor-made remedy to fit each individual's genes. Enough of practicalities: as with the moon shots, the lasting benefits of the human genome project will flow not from reaching the narrow goal itself but from learning how to reach it. The new skills will be turned towards other goals.

The chimpanzee genome will be sequenced in a fraction of the time taken for the human genome, which it closely resembles. The distinguished molecular biologist Sydney Brenner has made the startling suggestion that a sophisticated comparison of the two might then enable us to reconstruct the genome of the common ancestor that we share, the so-called missing link, which lived in Africa about six million years ago.

Extrapolating Brenner's logic, our computers should then be able to split the difference between the missing link and ourselves, approximating the genome of an Australopithecine such as "Lucy", the famous three-million-year-old ape woman fossilised in the Ethiopian highlands.

Such speculation is for the future, but it is a future measured in decades, not centuries. During the same decades, embryological science and cloning technology will also be advancing, and it is not excessive to speculate that, by 2050, a reconstructed Australopithecine genome might be used to bring into the world a living, breathing Lucy! And, by the same methods, a living Turkana Boy (Homo erectus, roughly intermediate between Lucy and us) and similar resurrections of the bridges that span the chimpanzee line of descent.

Many of us will be horrified, rather than excited, by such a suggestion. But we are not living in 2050. Things will seem different then. Though free from irrational fears of "playing God," I admit to misgivings, which stem from compassion for the Lucy herself. It seems all too likely that she will be victimised and exploited as a tabloid freak show. On the other hand, I see positive ethical benefits flowing from the experiment, in the form of changes to our own attitudes. The same benefits in moral education would be delivered by a successful hybridisation of a human and a chimpanzee. Or from the discovery of a relict population of Lucys, surviving somewhere in the African bush. But cloning a new Lucy is more practicable, and it would shatter our speciesist illusions very effectively.

People who cheerfully eat cows object violently to abortion. Not even the most vehement "pro-lifer" would claim that a human foetus feels pain, or distress, or fear, more than an adult cow. The double standard, therefore, stems from an absolutist regard for the humanity of the foetus. Even if we don't eat chimpanzees (and they are eaten in Africa, as bushmeat) we do treat them in otherwise inhuman ways. We incarcerate them for life without trial (in zoos). If they become surplus to requirements, or grow old and miserable, we call the vet to put them down. I am not objecting to these practices, simply calling attention to the double standard. Much as I'd like the vet to put me down when I'm past it, he'd be tried for murder because I'm human.

Human means special, unique, sacred, of infinite worth, to be venerated as the possessor of "human dignity." Animal means to be treated kindly but put to human use, painlessly destroyed when usefulness is past, killed for sport, or as a pest. A rogue lion that kills people will be shot, not in revenge, not as a punishment, not as a deterrent to other lions, not to satisfy the relatives of the victim, but simply to get it out of the way: not punishment, but pest control. A rogue human who kills people will be given a fair trial, and if sentenced will probably not be killed. If he is killed, it will be with grisly ceremony, after appeals, and in the face of massive, principled objection. Of all the justifications offered for capital punishment, one that will never be heard is pest control. It has no place in penal theory. Humans, to the absolutist mind, are forever divided from "animals."

A real, live Lucy would drive a coach and horses through this double standard. Of course we already know that we are cousins of chimpanzees. But the intermediates are all conveniently dead, so it is easy to forget. If we succeed in cloning a Lucy and a series of graded, mutually fertile intermediates linking us to chimpanzees, what would the pro-"lifers" do then, poor things?

At the height of the apartheid idiocy, the South Africans set up courts to determine whether individuals should "pass for white." These obscene courts sometimes separated brothers, where one happened to be darker than the other. The pro-"lifers" would either have to go down that preposterous route, or embrace chimpanzees as human. And then, of course, we would be on the slippery slope, via gorillas, orang-utans, monkeys and so on, to the entire animal kingdom. This will not worry those of us who were never absolutists in the first place: who care more for the individual's capacity to suffer than for his divine human status. But it shows absolutism up as incoherent.

The silly thing is that it shouldn't be necessary to clone a live Lucy. Anyone with an intelligent imagination should get the point from the undeniable fact that we animals are all cousins: it is the merest accident that the evolutionary intermediates happen to be extinct. But the absolutist mind - one of the great scourges of humanity - has never been richly endowed with either intelligence or imagination. Unfortunately, the absolutist mind needs to see the word made flesh. Come back Lucy!

Home Christine DeBlase-Ballstadt

Burying the Vehicle

Commentary by Richard Dawkins

Published in Behavioral and Brain Sciences, Vol.17, No.4, pp.616-617 (1994). Remarks on an earlier article by Elliot Sober and David Sloan Wilson, who made a more extended argument in their recent book Unto Others : The Evolution and Psychology of Unselfish Behavior

Wilson and Sober's passion is obviously genuine. I welcome their plainly sincere attempt at clarification and, despite myself, I quite enjoy the rhetoric. They are zealots, baffled by the failure of the rest of us to agree with them. I can sympathsize: I remain reciprocally baffled by what I still see as the sheer, wanton, head-in-bag perversity of the position that they champion. You see, we really do agree about so much. We come so close to being like that. We agree about the fundamental importance of the replicator/vehicle distinction. We agree that genes are replicators, organisms and groups are not. We agree that the group selection controversy ought to be a controversy about groups as vehicles, and we could easily agree to differ on the answer. But why, having talked so much sense, do they spoil it all at the bottom line by pretending that their kind of group as vehicle selection has any illuminating similarity with the kind of group selection that Allee, Emerson and Co uncritically misused to explain altruism? They call that kind of group-selectionism naive, which is right. But then they go right ahead and talk of re-introducing it. Please don't re-introduce something naive that deserved to be dropped.

We also agree that the individual organism has been oversold on the campus. Far from championing the organism, The Extended Phenotype is best seen as an attack on the organism and this should be music to Wilson's and Sober's ears. I coined the vehicle not to praise it but to bury it. This is, paradoxically, why vehicle is a better name than Hull's interactor. Interactor comes too close to the (messy) truth and therefore doesn't merit a helpfully decisive burial.

Selection chooses only replicators such as DNA molecules and, conceivably, units of cultural inheritance. Replicators are judged by their phenotypic effects. Phenotypic effects may happen to be bundled, together with the phenotypic effects of other replicators, in vehicles. Those vehicles often turn out to be the objects that we recognise as organisms but this didn't have to be so. It isn't part of the definition of a vehicle. There didn't have to be any vehicles at all. Darwinism can work on replicators whose phenotypic effects (interactors) are too diffuse, too multi-levelled, too incoherent to deserve the accolade of vehicle. Extended phenotypes can include inanimate artifacts like beaver dams. They can even include phenotypic characteristics manifesting themselves in other individuals and other species. The very existence of discrete vehicles is something that needs an explanation, in the same sense as the existence of sex needs an explanation. No doubt there are good explanations and I essayed three myself in The Extended Phenotype. But the vehicle is not something fundamental, in terms of which other explanations should be framed. You should not feel entitled to ask: "What is the vehicle in this situation?"

The cooperative crickets, sculling like Mole and Ratty in unison towards their lily pad, are enchanting. But it is deeply unhelpful to claim that the pair is the vehicle of selection. There is no vehicle of selection in this case. It is a terrific vehicle-undermining example. Natural selection favours replicators that prosper in their environment. The environment of a replicator includes the outside world but it also includes, most importantly, other replicators, other genes in the same organism and in different organisms, and their phenotypic products. Cricket genes for cooperating in the presence of another cooperating cricket prosper. This statement is true and illuminating, in precisely the same sense as the statement that genes for thick hairy coats prosper in the presence of snow. Like snow, each cricket is part of the environment of the other one's genes.

It would be unfair to accuse Wilson and Sober of including the snow as part of that which is selected, although it would follow from my view of the world that that is what they are, in effect, doing. But it would be only slightly unfair to offer the following challenge to Wilson and Sober. Figs depend obligately on fig-wasps for pollination, and fig-wasps are obligately dependent on fig ovules for food. Each species of fig has its own private species of fig wasp and neither can survive without the other. The underlying game is almost certainly isomorphic with that being played by the two harmonious crickets. Wilson and Sober should, to be consistent, say that {Fig + Wasp} is the vehicle. Maybe they would. But now suppose that a fig species is equally dependent on a particular species of monkeys to spread its seeds in their dung, and the monkeys are completely dependent on the same figs for their food. Here {Fig + Monkey} is the vehicle. We descend into a criss-crossing, interlocking nightmare of Venn diagrams, but only if we insist on parcelling things up into discrete vehicles in the first place. To push to the reductio ad absurdum, aren't Wilson and Sober perilously close to saying of a specialist predator and its uniquely endangered prey, whose shapes and behaviour have been sculpted over many generations by a mutual arms race, that the pair of them constitute a joint vehicle?

Natural selection chooses replicators for their ability to survive in an environment that includes other replicators and their products. Sometimes cooperation among replicators is so strongly favoured that units coherent enough to be called vehicles emerge. But just because a vehicle may emerge at a given level, we have no right to assume that it will and I believe the evidence will show that at most levels it usually doesn't. The question, "What is the vehicle in this situation?" may be no more justified than "What is the purpose of Mount Everest?" Ask rather "Is there a vehicle in this situation and, if so, why?"

Children must choose their own beliefs

In an open letter to Estelle Morris, Richard Dawkins calls on the Government to think again about funding yet more divisive faith schools
Article in The Observer Sunday December 30, 2001

Dear Secretary of State,

The Government has decided, reasonably enough, that heredity is no basis for membership of Parliament, and the hereditary peers are either gone or on their way. Yet, in the very same year, you propose increasing the number of faith schools. Having disavowed the hereditary principle for membership of Parliament, you seem hell-bent on promoting the hereditary principle for the transmission of beliefs and opinions. For that is precisely what religions are: hereditary beliefs and opinions. To quote the headline of a fine article in the Guardian last week by the Reverend Don Cupitt: 'We need to make a clean break with heritage religion and create something better suited to our own time.'

We vary in our opinions and our tastes, and it is one of our glories. Some of us are left-wing, others right. Some are pro-euro, others anti-. Some listen to Beethoven, others Armstrong. Some watch birds, others collect stamps. It is only to be expected that our elders should influence us in all such matters. All this is normal and praiseworthy.

In particular, it is normal and pleasing that parental impact should be strong. I'm not talking particularly about genes, but about all the influences that parents inevitably bring. It is to be expected that cricketing fathers will bowl to their sons - or daughters - on the back lawn, take them to Lords, and pass on their love of the game. There will be some tendency for ornithologists to have bird-watching children, bibliophiles book-loving children. Beliefs and tastes, political biases and hobbies, these will tend, at least statistically, to pass longitudinally down generations, and nobody would wish it otherwise.

But now we come to religion, and an extremely odd thing happens. Where we might have said, 'knowing his father, I expect young Cowdrey will take up cricket,' we emphatically do not say, 'With her devout Catholic parents, I expect young Bernadette will take up Catholicism.' Instead we say, without a moment's hesitation or a qualm of misgiving, 'Bernadette is a Catholic'. We state it as simple fact even when she is far too young to have developed a theological opinion of her own. In all other spheres, a good school will encourage her to develop her own tastes and opinions, her own skills, penchants and values. But when it comes to religion, society meekly makes a clanging exception. We inexplicably accept that, the day she is born, Bernadette has a label tied around her neck. This is a Catholic baby.

That is a protestant baby. This is a Hindu baby. That is a Muslim baby. This baby thinks there are many gods. That baby is adamant that there is only one. But it is preposterous that we do this to children. They are too young to know what they think. To slap a label on a child at birth - to announce, in advance, as a matter of hereditary presumption if not determinate certainty, an infant's opinions on the cosmos and creation, on life and afterlives, on sexual ethics, abortion and euthanasia - is a form of mental child abuse.

I do not believe it is possible to mount a decent defence against my charge. Yet infant belief-labels are almost universally accepted. We don't even think about it. Just in case any lingering doubt remains, consider the following: This child is a Gramscian Marxist. That child is a Trotskyite Syndicalist. This third child is a Wet Conservative. This baby is a Keynesian. That baby is a Monetarist. This baby is an ornithologist. Not, 'This baby is likely to become an ornithologist if his father has anything to do with it.' That would be fine. But, 'this baby is an ornithologist'? Unthinkable, isn't it? Yet, where religion is concerned, you don't give it a second glance. Oh, and by the way, nobody, least of all an atheist, ever talks about an 'atheist child'. Rightly so. But why the double standard?

I presume you need no more convincing. For parents to influence their children's opinions and beliefs is inevitable and proper. But to tie labels to young children, which in effect presume and presuppose the success of that parental influence, is wicked and indefensible. But, you may soothingly say, don't worry, wait till they go to school, it'll be fine. The children will be educated in a variety of opinions and beliefs, they'll be taught to think for themselves, they'll make up their own minds. Well, it would have been nice to think so.

But what do we do? We deliberately set up, and massively subsidise, segregated faith schools. As if it were not enough that we fasten belief-labels on babies at birth, those badges of mental apartheid are now reinforced and refreshed. In their separate schools, children are separately taught mutually incompatible beliefs.

'Protestant children' go to the state-subsidised Protestant school. If they are lucky, they won't actually be taught to hate Catholics, but I wouldn't bank on it, especially in Northern Ireland. The best we can hope for is that they will come out thinking only that there is something a bit alien or odd about Catholics. 'Catholic children' go to the Catholic school. Even if they are not taught to hate Protestants (again, don't bank on it), and even if they don't have to run the gauntlet of hate in the Ardoyne, we can be sure they won't be taught the same Irish history as the 'Protestant children' down the street.

Secretary of state, even if I fail to convince you that opening new faith schools is downright insane, may I at least plead for a consciousness-raising exercise in your own department? Just as feminists succeeded in making us wince when we hear 'he' where no sex is intended, or 'man' for humanity, we need to raise our consciousness about the faith-labelling of children.

Please, I beg you, strongly discourage the use, in all ministerial documents and inter-departmental memos, of phrases that presume theological opinions in children too young to have any. Please foster a climate in which it becomes impossible to use a phrase like 'Catholic children', 'Protestant children', 'Jewish children' or 'Muslim children' without wincing. It only costs two words more to say, for instance, 'children of Muslim parents' or 'children of Jewish parents'.

One of the more frightening aspects of human nature is a tendency to gravitate towards 'Us' and against 'Them'. Worse, Us versus Them disputes have a natural tendency to reach down the generations, leading to vendettas of frightening historical tenacity. Where labels are not provided to feed our natural divisiveness, we manufacture them. Children separate out into gangs, often with distinguishing labels. In certain districts of Los Angeles, a young person innocently sporting the wrong brand of trainers is in danger of being shot. Experiments have been done in which children, with no particular reason to sort themselves into gangs, are provided with, say, green or blue labels. In short order, enmities spring up between the greens and the blues: fierce loyalties to one's own colour, vendettas against the other. These can become surprisingly vicious.

That's what happens when you don't even try to segregate children. Now, imagine that you deliberately stamp a green or a blue label on a child at birth. Send this child to a blue school and that child to a green school. Encourage green boys to assume that they will grow up to marry green girls, while blue girls will marry blue boys. Take for granted that, the moment they have a baby of their own, it too must have the same coloured label tied around its neck. Passed on down the generations, what is all that a recipe for? Do I need to spell it out?

The very idea of a faith school is as unjustifiable as the idea of a hereditary House of Lords, and for the same reason. But hereditary peers, though undemocratic and often mildly eccentric, are not dangerous. Faith schools almost certainly are. There remains the pragmatic argument that, notwithstanding the knockdown objection to the principle of faith schools, they get good exam results. Well, maybe. If it is true, by all means let's try to bottle the secret, and share it around. But, bottled or not, careful analysis fails to uncover any real link with faith. The ingredient in the bottle is a school ethos, which can take years to grow and which, for reasons having no connection with religion, has become built up in certain Church of England and Roman Catholic schools. A high reputation, once built, is self-perpetuating, because ambitious, education-loving parents gravitate towards it, even to the extent of pretending to be churchgoers.

But in any case, where have we heard something like the pragmatic, 'exam results' argument before? Yes, in the debate over the hereditary peers. People were fond of saying that, no matter how undemocratic was the principle of hereditary members of Parliament, they got results. Enough aristocrats worked hard, some were real experts on fly fishing, or windmills; some were doctors who had wise things to say about the health service; many were farmers who could hold forth on foot and mouth or the Common Agricultural Policy; and all of them preserved the decencies of debate, unlike that rabble in the Commons. Undemocratic they may have been, but they did a good job.

That argument cut no ice with the Government, and rightly so. If you gather together a bunch of men of above average wealth and education, raised in book-lined homes for many generations, it is hardly surprising that some expertise and talent will surface. The pragmatic argument, that hereditary peers do a good job, is on the slippery slope to 'say what you like about Mussolini, at least he made the trains run on time'. There are limits beyond which principle should not be dragged by pragmatism. The Government reached that limit over the hereditary peers. The pragmatic case in favour of faith schools is similar, but weaker. The principled case against faith schools is similar, but stronger.

As for what is to be done, of course we don't want to destroy institutions that are working well. The way to be fair to hitherto unsupported denominations is not to give them their own sectarian schools, but to remove the faith status of the existing schools (just as the fair way to balance the bishops in the Lords is not to invite mullahs, monsignors and rabbis to join them, but to throw the existing bishops out). After everything we've been through this year, to persist with financing segregated religion in sectarian schools is obstinate madness.

Yours very sincerely,

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Close Encounters with the Truth
Review of Carl Sagan's: The Demon-Haunted World

Review published in The Times (London) February 1996
by Richard Dawkins

As I close this eloquent and fascinating book, I recall the final chapter title from one of Carl Sagan's earlier works, Cosmos. 'Who Speaks for Earth?' is a rhetorical question that expects no particular answer, but I presume to give it one. My candidate for planetary ambassador, my own nominee to present our credentials in galactic chancelleries, can be none other than Carl Sagan himself. He is wise, humane, polymathic, gentle, witty, well-read, and incapable of composing a dull sentence. I confess to the habit, when reading books, of underlining occasional sentences that I particularly like. The Demon-Haunted World forced me to desist, simply to save on ink. But how can I not quote Sagan's answer to the question why he bothers to work at explaining science?
"Not explaining science seems to me perverse. When you're in love, you want to tell the world. This book is a personal statement, reflecting my lifelong love affair with science."

Buoyant and uplifting though much of the book is, its subtitle is 'Science as a Candle in the Dark' and it ends in foreboding. Science – not the facts of science but the scientific method of critical thought – "may be all that stands between us and the enveloping darkness". The dark is the dark of mediaeval and modern witch-hunts, of the pathological dread of nonexistent demons and UFOs, of humanity's wanton gullibility in the face of fatcat mystics and the obscurantist gurus of postmodern metatwaddle. One of Sagan's most chilling quotes is a call to arms against science, from a book published in 1995, which concludes:
"Science itself is irrational or mystical. It's just another faith or belief system or myth, with no more justification than any other. It doesn't matter whether beliefs are true or not, as long as they're meaningful to you."

Truth has its enemies as Sagan documents. But, perhaps because he doesn't live in Britain, he overlooks a separate problem faced by science in our culture: a philistine double standard. When the Daily Telegraph reported a survey finding that a high percentage of adults think the Sun goes round the Earth, the then Editor inserted, "Doesn't it? Ed." One immediately thinks of Bernard Levin's preening delight in his own ignorance, or of the patronising snigger with which television announcers render science stories as the concluding 'joke' item at the end of the news. If a survey found that 50% of adults believe Shakespeare wrote The Iliad, what Editor would find it funny to insert a parenthetic "Didn't he? Ed."? That's the double standard. Again, when the aggressive habits of Rottweilers were being excitedly promoted by the news media a while ago, the responsible government minister went on the radio to reveal the disturbing extent of the problem. Dogs, she explained patiently, don't have DNA. Ignorance on such a scale would not be countenanced in a Minister of the Crown, were the subject anything other than science.

Among the gifts science has to offer is, in Sagan's words, a baloney detection kit. His book is in part a manual for using the kit. Here is how to test the credentials of the superhuman extraterrestrials who annually swarm to Earth in UFOs and abduct humans for sexual experiments (to the victims' considerable profit when they sell their stories to the inexhaustibly gullible – or cynical – press).
"Occasionally, I get a letter from someone who is in 'contact' with extraterrestrials. I am invited to 'ask them anything'. And so over the years I've prepared a little list of questions. The extraterrestrials are very advanced, remember. So I ask things like, 'Please provide a short proof of Fermat's Last Theorem'. Or the Goldbach Conjecture. . . I never get an answer. On the other hand, if I ask something like 'Should we be good?' I almost always get an answer. Anything vague, especially involving conventional moral judgements, these aliens are extremely happy to respond to. But on anything specific, where there is a chance to find out if they actually know anything beyond what most humans know, there is only silence".

Scientists are sometimes suspected of arrogance. Sagan commends to us by contrast the humility of the Roman Catholic Church which, as early as 1992, was ready to pardon Galileo and admit publicly that the Earth does revolve around the Sun. We must hope that this outspoken magnanimity will not cause offence or 'hurt' to "the supreme religious authority of Saudi Arabia, Sheik Abdel-Aziz Ibn Baaz" who, in 1993, "issued an edict, or fatwa, declaring that the world is flat. Anyone of the round persuasion does not believe in God and should be punished". Arrogance? Scientists are amateurs in arrogance.

Moreover, they have a modicum to be arrogant about: Scientists . . .

“. . . can routinely predict a solar eclipse, to the minute, a millennium in advance. You can go to the witch doctor to lift the spell that causes your pernicious anaemia, or you can take Vitamin B12. If you want to save your child from polio, you can pray or you can inoculate. If you’re interested in the sex of your unborn child, you can consult plumb-bob danglers all you want . . . but they’ll be right, on average, only one time in two. If you want real accuracy . . . try amniocentesis and sonograms. Try science.”

I wish I had written The Demon-Haunted World. Having failed to do so, the least I can do is press it upon my friends. Please read this book.

END

Richard Dawkins is the first holder of Oxford’s newly endowed Charles Simonyi Chair in the Public Understanding of Science. His new book, Climbing Mount Improbable, will be published by Viking in April

Darwin and Darwinism
by Richard Dawkins
A longer version of this article, authored by Richard Dawkins, first appeared in the British Edition of Microsoft(r) Encarta(r) Encyclopedia 98.

To most people through history it has always seemed obvious that the teeming diversity of life, the uncanny perfection with which living organisms are equipped to survive and multiply, and the bewildering complexity of living machinery, can only have come about through divine creation. Yet repeatedly it has occurred to isolated thinkers that there might be an alternative to supernatural creation. the notion of species changing into other species was in the air, like so many other good ideas, in ancient Greece. It went into eclipse until the 18th century, when it resurfaced in the minds of such advanced thinkers as Pierre de Maupertuis, Erasmus Darwin and the man who styled himself the Chevalier de Lamarck. In the first half of the 19th century the idea became not uncommon in intellectual circles, especially geological ones, but always in a rather vague form and without any clear picture of the mechanism by which change might come about. It was Charles Darwin (Erasmus's grandson) who, spurred into print by Alfred Russel Wallace's independent discovery of his principle of natural selection, finally established the theory of evolution by the publication, in 1859, of the famous book whose title is usually abbreviated to the Origin of Species.

We should distinguish two quite distinct parts of Darwin's contribution. He amassed an overwhelming quantity of evidence for the fact that evolution has occurred, and, together with Wallace (independently) he thought up the only known workable theory of the reason why it leads to adaptive improvement – natural selection.

Some fossil evidence was known to Darwin but he made more use of other evidence, less direct but in many ways more convincing, for the fact that evolution had taken place. the rapid alteration of animals and plants under domestication was persuasive evidence both for the fact that evolutionary change was possible and for the effectiveness of the artificial equivalent of natural selection. Darwin was particularly persuaded by the evidence from the geographical dispersion of animals. the presence of local island races, for example, is easily explicable by the evolution theory: the creation theory could explain them only by unparsimoniously assuming numerous 'foci of creation' dotted around the earth's surface. the hierarchical classification into which animals and plants fall so naturally is strongly suggestive of a family tree: the creation theory had to make contrived and elaborate assumptions about the creator's mind running along themes and variations. Darwin also used as evidence for his theory the fact that some organs seen in adults and embryos appear to be vestigial. According to the evolution theory such organs as the tiny buried hind-limb bones of whales are remnants of the walking legs of their terrestrial ancestors. In general the evidence for the fact that evolution has occurred consists of an enormous number of detailed observations which all make sense if we assume the theory of evolution, but which can be explained by the creation theory only if we assume that the creator elaborately set out to deceive us. Modern molecular evidence has boosted the evidence for evolution beyond Darwin's wildest dreams, and the fact of evolution is now as securely attested as any in science.

Turning from the fact of evolution to the less secure theory of its mechanism, natural selection, the mechanism that Darwin and Wallace suggested, amounts to the nonrandom survival of randomly varying hereditary characteristics. Other British Victorians, such as Patrick Matthew and Edward Blyth, had suggested something like it before, but they apparently saw it as a negative force only. Darwin and Wallace seem to have been the first to realise its full potential as a positive force guiding the evolution of all life in adaptive directions. Most previous evolutionists, such as Darwin's grandfather Erasmus, had inclined towards an alternative theory of the mechanism of evolution, now usually associated with Lamarck's name. This was the theory that improvements acquired during an organism's lifetime, such as the growth of organs during use and their shrinkage during disuse, were inherited. This theory of the inheritance of acquired characteristics has emotional appeal (for example to George Bernard Shaw in his Preface to Back to Methuselah) but the evidence does not support it. Nor is it theoretically plausible. In Darwin's time the matter was more in doubt, and Darwin himself flirted with a personalised version of Lamarckism when his natural selection theory ran into a difficulty.

That difficulty arose from current views of the nature of heredity. In the 19th century it was almost universally assumed that heredity was a blending process. On this blending inheritance theory, not only are offspring intermediate between their two parents in character and appearance, but the hereditary factors that they pass on to their own children are themselves inextricably merged. It can be shown that, if heredity is of this blending type, it is almost impossible for Darwinian natural selection to work because the available variation is halved in every generation. Darwin knew this, and it worried him enough to drive him in the direction of Lamarckism. It may also have contributed to the odd fact that Darwinism suffered a temporary spell of unfashionableness in the early part of the 20th century. the solution to the problem which so worried Darwin lay in Gregor Mendel's theory of particular inheritance, published in 1865 but unfortunately unread by Darwin, or practically anyone else until after Darwin's death.

Mendel's research, rediscovered at the turn of the century, demonstrated, what Darwin himself had at one time dimly glimpsed, that heredity is particulate, not blending. Whether or not offspring are bodily intermediate between their two parents, they inherit, and pass on, discrete hereditary particles – nowadays we call them genes. An individual either definitely inherits a particular gene from a particular parent or it definitely does not. Since the same can be said of its parents, it follows that an individual either inherits a particular gene from a particular grandparent or it does not. Every one of your genes comes from a particular one of your grandparents and, before that, from a particular one of your great grandparents. This argument can be applied repeatedly for an indefinite number of generations. Discrete single genes are shuffled independently through the generations like cards in a pack, rather than being mixed like the ingredients of a pudding.

This makes all the difference to the mathematical plausibility of the theory ofnatural selection. If heredity is particulate, natural selection really can work. As was first realised by the British mathematician G H Hardy and the German scientist W Weinberg, there is no inherent tendency for genes to disappear from the gene pool. If they do disappear, it will be because of bad luck, or because of natural selection – because something about those genes influences the probability that individuals possessing them will survive and reproduce. the modern version of Darwinism, often called Neodarwinism, is based upon this insight. It was worked out in the 1920s and 1930s by the population geneticists R A Fisher, J B S Haldane and Sewall Wright, and later consolidated into the synthesis of the 1940s known as Neodarwinism. the recent revolution in molecular biology, beginning in the 1950s, has reinforced and confirmed, rather than changed, the synthetic theory of the 1930s and 40s.

the modern genetic theory of natural selection can be summarised as follows. the genes of a population of sexually interbreeding animals or plants constitute a gene pool. the genes compete in the gene pool in something like the same way as the early replicating molecules competed in the primeval soup. In practice genes in the gene pool spend their time either sitting in individual bodies which they helped to build, or travelling from body to body via sperm or egg in the process of sexual reproduction. Sexual reproduction keeps the genes shuffled, and it is in this sense that the long-term habitat of a gene is the gene pool. Any given gene originates in the gene pool as a result of a mutation, a random error in the gene-copying process. Once a new mutation has been formed, it can spread through the gene pool by means of sexual mixing. Mutation is the ultimate origin of genetic variation. Sexual reproduction, and genetic recombination due to crossing over see to it that genetic variation is rapidly distributed and recombined in the gene pool.

Any given gene in a gene pool is likely to exist in the form of several duplicate copies, either all descended from the same original mutant, or descended from independent parallel mutants. therefore each gene can be said to have a frequency in the gene pool. Some genes, such as the albino gene, are rare in the gene pool, others are common. At the genetic level, evolution may be defined as the process by which gene-frequencies change in gene pools.

there are various reasons why gene-frequencies might change: immigration, emigration, random drift, and natural selection. Immigration, emigration, and random drift are not of much interest from the point of view of adaptation, although they may be quite important in practice. It is natural selection which accounts for the perfection of adaptation, for the complex functional organisation of life, and for such progressive qualities as evolution may (controversially) exhibit. Genes in bodies exert an influence on the development of those bodies. Some bodies are better at surviving and reproducing than others. Good bodies, i.e. bodies that are good at surviving and reproducing, will tend to contribute more genes to the gene pools of the future than bodies that are bad at surviving and reproducing: genes that tend to make good bodies will come to predominate in gene pools. Natural selection is the differential survival and differential reproductive success of bodies: it is important because of its consequences for the differential survival of genes in gene pools.

Not all selective deaths lead to evolutionary change. On the contrary, much natural selection is so-called stabilising selection, removing genes from the gene pool that tend to cause deviation from an already optimal form. But when environmental conditions change, either through natural catastrophe or through evolutionary improvement of other creatures (predators, prey, parasites, and so on), selection may lead to evolutionary change.

Evolution under the influence of natural selection leads to adaptive improvement. Evolution, whether under the influence of natural selection or not, leads to divergence and diversity. From a single ultimate ancestor, many hundreds of millions of separate species have, at one time or another, evolved. the process whereby one species splits into two is called speciation. Subsequent divergence leads to ever wider separation of taxonomic units – genera, families, orders, classes, etc. Even creatures as different as, say, snails and monkeys, are derived from ancestors who originally diverged from a single species in a speciation event.

Since the 1940s it has been widely accepted that the first step in the origin of species is normally geographical separation. A species is accidentally divided into two geographically separated populations. Often there may be sub-populations isolated on islands, where the word is generalised to include islands of water in land (lakes), islands of vegetation in deserts (oases) etc. Even trees in a meadow may be effective islands to some of their small inhabitants. Geographical isolation means no gene flow, no sexual contamination of each gene pool by the other. Under these conditions the average gene frequencies in the two gene pools can change, either because of different selection pressures or because of random statistical changes in the two areas, After sufficient genetic divergence while in geographical isolation, the two sub-populations are no longer capable of interbreeding even if later circumstances chance to re-unite them. When they can no longer interbreed, speciation is said to have occurred and a new species (or two) is said to have come into being. It is controversial whether geographical separation is always necessarily implicated in speciation.

Darwin made a distinction between natural selection, which favours organs and devices for survival, and sexual selection which favours competitive success in gaining mates, either by direct combat with members of the same sex, or by being attractive to the opposite sex (these are sometimes called intrasexual selection and intersexual selection, respectively, but the usage is misleading). Darwin was impressed by the fact that qualities of sexual attractiveness were often the reverse of qualities leading to individual survival. the gaudy and cumbersome tails of birds of paradise are a notorious example. they must hamper their possessors in flight, and certainly they are conspicuous to predators, but Darwin realised that this could be 'worth it' if the tails also attractive females. A male who manages to persuade a female to mate with him rather than with a rival is likely to contribute his genes to future gene pools. Genes for sexually attractive tails willy-nilly have an advantage that compensates for their admitted disadvantages.

the philosopher Daniel Dennett has written: "Let me lay my cards on the table. If I were to give an award for the single best idea anyone has ever had, I'd give it to Darwin, ahead of Newton and Einstein and everyone else." Comparative judgments like that are hard to make. But on one criterion Darwin's contribution surely heads the field. the sheer power of the idea, measured as the amount of explanatory work that it does, divided by the extreme simplicity of the idea itself, leaves one astonished that humanity had to wait till the mid nineteenth century before one of us thought of it.

A longer version of this article, authored by Richard Dawkins, first appeared in the British Edition of Microsoft(r) Encarta(r) Encyclopedia 98.

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"Dolly and the cloth-heads" *
by Richard Dawkins
* title was chosen by the editor

Published in The Independent newspaper on Saturday 8th March 1997

The admirable Dolly the sheep must have felt her cloned ears burning this week. She has seldom been off the air, seldom far from the Comment columns, the Leader pages or the Letters to the Editor.

What has intrigued me is the process by which invited contributors to the broadcast debates on such delicate matters are chosen. Some of them are experts in the field, as you would expect and as is right and proper. Others are distinguished scholars of moral or legal philosophy, which is equally appropriate.

Both these categories of person have been invited in their own right, because of their expert knowledge or their proven ability to think intelligently and express themselves clearly. The arguments they have with each other are usually illuminating and rewarding.

But there is another category of obligatory guest. There is the inevitable "representative" of the so-and-so "community"; and, of course, we mustn't forget the "voice" from the such-and-such "tradition". Not to mince words, the religious lobby. Lobbies in the plural, I should say, because all the religions have their point of view, and they all have to be represented lest their respective "communities" feel slighted.

This has the incidental effect of multiplying the sheer number of people in the studio, with consequent consumption, if not waste, of time. It also, I believe, often has the effect of lowering the level of expertise and intelligence. This is only to be expected, given that these spokesmen are chosen not because of their own qualifications in the field, or as thinkers, but simply because they represent a particular section of the community.

Out of good manners I shall not mention names, but this week I have experienced public discussions of cloning with several prominent religious leaders, and it has not been edifying. One of the most eminent of these spokesmen, recently elevated to the House of Lords, got off to a flying start by refusing to shake hands with the women in the studio, apparently for fear that they might be menstruating or otherwise "unclean".

They took the insult graciously, and with the "respect" always bestowed on religious prejudice (but no other kind of prejudice). The spokesman then, when asked what harm cloning might do, answered that atomic bombs were harmful. No disagreement there, but the discussion was in fact supposed to be about cloning.

Since it was his choice to shift the discussion to atomic bombs, perhaps he knew more about physics than about biology? But, no, having delivered himself of the daring falsehood that Einstein split the atom, he switched with confidence to geological history. He made the telling point that, since God laboured six days and then rested on the seventh, scientists, too, ought to know when to call a halt.

Now, either he really believed that the world was made in six days, in which case his ignorance alone disqualifies him from being taken seriously. Or, as the presenter charitably suggested, he intended the point purely as an allegory - in which case it was a lousy allegory.

Sometimes in life it is a good idea to stop; sometimes it is a good idea to go on . The trick is to decide when to stop. The allegory of God resting on the seventh day cannot, in itself, tell us whether we have reached the right point to stop in some particular case. As allegory, the six-day creation story is empty. As history, it is false. So why bring it up?

The representative of a rival religion on the same panel was frankly confused. He feared that a human clone would lack individuality. It would not be a whole, separate human being but a mere soulless automaton.

When one of the scientists mildly suggested that he might be hurting the feelings of identical twins, he said that identical twins were a quite different case. Why? Because they occur naturally, rather than under artificial conditions. Once again, no disagreement about that. But weren't we talking about "individuality", and whether clones are "whole human beings" or soulless automata?

This religious spokesman seemed simply unable to grasp that there were two separate arguments going on: first, whether clones are autonomous individuals (in which case the analogy with identical twins is inescapable and his fear groundless); and second, whether there is something objectionable about artificial interference in the natural processes of reproduction (in which case other arguments should be deployed - but weren't). I don't want to sound uncharitable, but I respectfully submit to the producers who put together these panels that merely being a spokesman for a particular "tradition" or "community" may not be enough. Isn't a certain minimal qualification in the IQ department desirable, too?

On a different panel, this time on radio, yet another religious leader was similarly perplexed by identical twins. He too had theological grounds for fearing that a clone would not be a separate individual and would therefore lack "dignity".

He was swiftly informed of the undisputed scientific fact that identical twins are clones of each other with the same genes, exactly like Dolly the sheep except that Dolly's clone is older. Did he really mean to say that identical twins (and we all know some) lack the dignity of separate individuality? His reason for denying the relevance of the twin analogy was even odder than the previous one. Indeed it was transparently self-contradictory.

He had great faith, he informed us, in the power of nurture over nature. Nurture is why identical twins are really different individuals. When you get to know a pair of twins, he pointed out triumphantly, they even look a bit different.

Er, quite so. And if a pair of clones were separated by 50 years, wouldn't their respective nurtures be even more different? Haven't you just shot yourself in your theological foot? He just didn't get it - but, after all, he hadn't been chosen for his ability to follow an argument.

Religious lobbies, spokesmen of "traditions" and "communities", enjoy privileged access not only to the media but to influential committees of the great and the good, to the House of Lords (as I mentioned above), and to the boards of school governors.

Their views are regularly sought, and heard with exaggerated "respect", by parliamentary committees. Religious spokesmen and spokeswomen enjoy an inside track to influence and power which others have to earn through their own ability or expertise.

What is the justification for this? Maybe there is a good reason, and I'm ready to be persuaded by it. But, on the face of it, isn't there more justification for choosing expert witnesses for their knowledge and accomplishments as individuals, than because they represent some group or class of person? Come to think of it, in the light of all those worries about lack of individuality among clones, isn't there a touch of irony here? Maybe even a useful allegory? Ah, now, you're talking!

Don't turn your back on science - An open letter from biologist Richard Dawkins to Prince Charles

Article in The Observer Sunday May 21, 2000

Your Royal Highness,

Your Reith lecture saddened me. I have deep sympathy for your aims, and admiration for your sincerity. But your hostility to science will not serve those aims; and your embracing of an ill-assorted jumble of mutually contradictory alternatives will lose you the respect that I think you deserve. I forget who it was who remarked: 'Of course we must be open-minded, but not so open-minded that our brains drop out.'

Let's look at some of the alternative philosophies which you seem to prefer over scientific reason. First, intuition, the heart's wisdom 'rustling like a breeze through the leaves'. Unfortunately, it depends whose intuition you choose. Where aims (if not methods) are concerned, your own intuitions coincide with mine. I wholeheartedly share your aim of long-term stewardship of our planet, with its diverse and complex biosphere.

But what about the instinctive wisdom in Saddam Hussein's black heart? What price the Wagnerian wind that rustled Hitler's twisted leaves? The Yorkshire Ripper heard religious voices in his head urging him to kill. How do we decide which intuitive inner voices to heed?

This, it is important to say, is not a dilemma that science can solve. My own passionate concern for world stewardship is as emotional as yours. But where I allow feelings to influence my aims, when it comes to deciding the best method of achieving them I'd rather think than feel. And thinking, here, means scientific thinking. No more effective method exists. If it did, science would incorporate it.

Next, Sir, I think you may have an exaggerated idea of the natural ness of 'traditional' or 'organic' agriculture. Agriculture has always been unnatural. Our species began to depart from our natural hunter-gatherer lifestyle as recently as 10,000 years ago - too short to measure on the evolutionary timescale.

Wheat, be it ever so wholemeal and stoneground, is not a natural food for Homo sapiens. Nor is milk, except for children. Almost every morsel of our food is genetically modified - admittedly by artificial selection not artificial mutation, but the end result is the same. A wheat grain is a genetically modified grass seed, just as a pekinese is a genetically modified wolf. Playing God? We've been playing God for centuries!

The large, anonymous crowds in which we now teem began with the agricultural revolution, and without agriculture we could survive in only a tiny fraction of our current numbers. Our high population is an agricultural (and technological and medical) artifact. It is far more unnatural than the population-limiting methods condemned as unnatural by the Pope. Like it or not, we are stuck with agriculture, and agriculture - all agriculture - is unnatural. We sold that pass 10,000 years ago.

Does that mean there's nothing to choose between different kinds of agriculture when it comes to sustainable planetary welfare? Certainly not. Some are much more damaging than others, but it's no use appealing to 'nature', or to 'instinct' in order to decide which ones. You have to study the evidence, soberly and reasonably - scientifically. Slashing and burning (incidentally, no agricultural system is closer to being 'traditional') destroys our ancient forests. Overgrazing (again, widely practised by 'traditional' cultures) causes soil erosion and turns fertile pasture into desert. Moving to our own modern tribe, monoculture, fed by powdered fertilisers and poisons, is bad for the future; indiscriminate use of antibiotics to promote livestock growth is worse.

Incidentally, one worrying aspect of the hysterical opposition to the possible risks from GM crops is that it diverts attention from definite dangers which are already well understood but largely ignored. The evolution of antibiotic-resistant strains of bacteria is something that a Darwinian might have foreseen from the day antibiotics were discovered. Unfortunately the warning voices have been rather quiet, and now they are drowned by the baying cacophony: 'GM GM GM GM GM GM!'

Moreover if, as I expect, the dire prophecies of GM doom fail to materialise, the feeling of let-down may spill over into complacency about real risks. Has it occurred to you that our present GM brouhaha may be a terrible case of crying wolf?

Even if agriculture could be natural, and even if we could develop some sort of instinctive rapport with the ways of nature, would nature be a good role model? Here, we must think carefully. There really is a sense in which ecosystems are balanced and harmonious, with some of their constituent species becoming mutually dependent. This is one reason the corporate thuggery that is destroying the rainforests is so criminal.

On the other hand, we must beware of a very common misunderstanding of Darwinism. Tennyson was writing before Darwin but he got it right. Nature really is red in tooth and claw. Much as we might like to believe otherwise, natural selection, working within each species, does not favour long-term stewardship. It favours short-term gain. Loggers, whalers, and other profiteers who squander the future for present greed, are only doing what all wild creatures have done for three billion years.

No wonder T.H. Huxley, Darwin's bulldog, founded his ethics on a repudiation of Darwinism. Not a repudiation of Darwinism as science, of course, for you cannot repudiate truth. But the very fact that Darwinism is true makes it even more important for us to fight against the naturally selfish and exploitative tendencies of nature. We can do it. Probably no other species of animal or plant can. We can do it because our brains (admittedly given to us by natural selection for reasons of short-term Darwinian gain) are big enough to see into the future and plot long-term consequences. Natural selection is like a robot that can only climb uphill, even if this leaves it stuck on top of a measly hillock. There is no mechanism for going downhill, for crossing the valley to the lower slopes of the high mountain on the other side. There is no natural foresight, no mechanism for warning that present selfish gains are leading to species extinction - and indeed, 99 per cent of all species that have ever lived are extinct.

The human brain, probably uniquely in the whole of evolutionary history, can see across the valley and can plot a course away from extinction and towards distant uplands. Long-term planning - and hence the very possibility of stewardship - is something utterly new on the planet, even alien. It exists only in human brains. The future is a new invention in evolution. It is precious. And fragile. We must use all our scientific artifice to protect it.

It may sound paradoxical, but if we want to sustain the planet into the future, the first thing we must do is stop taking advice from nature. Nature is a short-term Darwinian profiteer. Darwin himself said it: 'What a book a devil's chaplain might write on the clumsy, wasteful, blundering, low, and horridly cruel works of nature.'

Of course that's bleak, but there's no law saying the truth has to be cheerful; no point shooting the messenger - science - and no sense in preferring an alternative world view just because it feels more comfortable. In any case, science isn't all bleak. Nor, by the way, is science an arrogant know-all. Any scientist worthy of the name will warm to your quotation from Socrates: 'Wisdom is knowing that you don't know.' What else drives us to find out?

What saddens me most, Sir, is how much you will be missing if you turn your back on science. I have tried to write about the poetic wonder of science myself, but may I take the liberty of presenting you with a book by another author? It is The Demon-Haunted World by the lamented Carl Sagan. I'd call your attention especially to the subtitle: Science as a Candle in the Dark .
• Richard Dawkins is the Charles Simonyi Professor of the Public Understanding of Science at Oxford University. His latest book is 'Unweaving the Rainbow'

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A response to Prince Charles' Reith Lecture

A Royal View... Back
The Prince of Wales

Presenter: James Naughtie: Good evening from Highgrove in Gloucestershire - the home of His Royal

Highness, the Prince of Wales, and welcome to this special programme to mark the end of this year's Millennium Reith lecture series. With me are the Prince of Wales and the five Reith lecturers, who over the past few weeks have dealt with our theme of sustainable development. They've travelled from all around the world to join in this discussion and we hope that our lecturers - an American scientist, an Indian academic, a European politician, a world businessman and the Director General of the World Health Organisation will pool their ideas and speak tonight of practical things. What can be done to keep the world safe for the generations still to come? But first let's hear the thoughts of His Royal Highness, the Prince of Wales.

Prince Charles: Like millions of other people around the world I've been fascinated to hear five eminent speakers share with us their thoughts hopes and fears about sustainable development based on their own experience. All five of those contributions have been immensely thoughtful and challenging. There have been clear differences of opinion and of emphasis between the speakers but there have also been some important common themes, both implicit and explicit. One of those themes has been the suggestion that sustainable development is a matter of enlightened self-interest. Two of the speakers used this phrase and I don't believe that the other three would dissent from it, and nor would I.

Self-interest is a powerful motivating force for all of us, and if we can somehow convince ourselves that sustainable development is in all our interests then we will have taken a valuable first step towards achieving it. But self-interest comes in many competing guises - not all of which I fear are likely to lead in the right direction for very long, nor to embrace the manifold needs of future generations. I am convinced we will need to dig rather deeper to find the inspiration, sense of urgency and moral purpose required to confront the hard choices which face us on the long road to sustainable development. So, although it seems to have become deeply unfashionable to talk about the spiritual dimension of our existence, that is what I propose to do.

The idea that there is a sacred trust between mankind and our Creator, under which we accept a duty of stewardship for the earth, has been an important feature of most religious and spiritual thought throughout the ages. Even those whose beliefs have not included the existence of a Creator have, nevertheless, adopted a similar position on moral and ethical grounds. It is only recently that this guiding principle has become smothered by almost impenetrable layers of scientific rationalism. I believe that if we are to achieve genuinely sustainable development we will first have to rediscover, or re-acknowledge a sense of the sacred in our dealings with the natural world, and with each other. If literally nothing is held sacred anymore - because it is considered synonymous with superstition or in some other way "irrational" - what is there to prevent us treating our entire world as some "great laboratory of life" with potentially disastrous long term consequences?

Fundamentally, an understanding of the sacred helps us to acknowledge that there are bounds of balance, order and harmony in the natural world which set limits to our ambitions, and define the parameters of sustainable development. In some cases nature's limits are well understood at the rational, scientific level. As a simple example, we know that trying to graze too many sheep on a hillside will, sooner or later, be counter productive for the sheep, the hillside, or both. More widely we understand that the overuse of insecticides or antibiotics leads to problems of resistance. And we are beginning to comprehend the full, awful consequences of pumping too much carbon dioxide into the earth's atmosphere. Yet the actions being taken to halt the damage known to be caused by exceeding nature's limits in these and other ways are insufficient to ensure a sustainable outcome. In other areas, such as the artificial and uncontained transfer of genes between species of plants and animals, the lack of hard, scientific evidence of harmful consequences is regarded in many quarters as sufficient reason to allow such developments to proceed.

The idea of taking a precautionary approach, in this and many other potentially damaging situations, receives overwhelming public support, but still faces a degree of official opposition, as if admitting the possibility of doubt was a sign of weakness or even of a wish to halt "progress". On the contrary, I believe it to be a sign of strength and of wisdom. It seems that when we do have scientific evidence that we are damaging our environment we aren't doing enough to put things right, and when we don't have that evidence we are prone to do nothing at all, regardless of the risks.

Part of the problem is the prevailing approach that seeks to reduce the natural world including ourselves to the level of nothing more than a mechanical process. For whilst the natural theologians of the 18th and 19th centuries like Thomas Morgan referred to the perfect unity, order, wisdom and design of the natural world, scientists like Bertrand Russell rejected this idea as rubbish. 'I think the universe' he wrote 'is all spots and jumps without unity and without continuity, without coherence or orderliness. Sir Julian Huxley wrote in

"Creation a Modern Synthesis" - that modern science must rule out special creation or divine guidance.' But why?

As Professor Alan Linton of Bristol University has written- 'evolution is a manmade theory to explain the origin and continuance of life on this planet without reference to a Creator.' It is because of our inability or refusal to accept the existence of a guiding hand that nature has come to be regarded as a system that can be engineered for our own convenience or as a nuisance to be evaded and manipulated, and in which anything that happens can be fixed by technology and human ingenuity. Fritz Schumacher recognised the inherent dangers in this approach when he said that 'there are two sciences - the science of manipulation and the science of understanding.'

In this technology driven age it is all too easy for us to forget that mankind is a part of nature and not apart from it. And that this is why we should seek to work with the grain of nature in everything we do, for the natural world is, as the economist Herman Daly puts it - 'the envelope that contains, sustains and provisions the economy, not the other way round.' So which argument do you think will win - the living world as one or the world made up of random parts, the product of mere chance, thereby providing the justification for any kind of development? This, to my mind, lies at the heart of what we call sustainable development. We need, therefore, to rediscover a reference for the natural world, irrespective of its usefulness to ourselves - to become more aware in Philip Sherrard's words of 'the relationship of interdependence, interpenetration and reciprocity between God, Man and Creation.'

Above all, we should show greater respect for the genius of nature's designs, rigorously tested and refined over millions of years. This means being careful to use science to understand how nature works, not to change what nature is, as we do when genetic manipulation seeks to transform a process of biological evolution into something altogether different. The idea that the different parts of the natural world are connected through an intricate system of checks and balances which we disturb at our peril is all too easily dismissed as no longer relevant.

So, in an age when we're told that science has all the answers, what chance is there for working with the grain of nature? As an example of working with the grain of nature, I happen to believe that if a fraction of the money currently being invested in developing genetically manipulated crops were applied to understanding and improving traditional systems of agriculture, which have stood the all- important test of time, the results would be remarkable. There is already plenty of evidence of just what can be achieved through applying more knowledge and fewer chemicals to diverse cropping systems. These are genuinely sustainable methods and they are far removed from the approaches based on monoculture which lend themselves to large- scale commercial exploitation, and which Vandana Shiva condemned so persuasively and so convincingly in her lecture. Our most eminent scientists accept that there is still a vast amount that we don't know about our world and the life forms that inhabit it. As Sir Martin Rees, the Astronomer Royal, points out, it is complexity that makes things hard to understand, not size. In a comment which only an astronomer could make, he describes a butterfly as a more daunting intellectual challenge than the cosmos!

Others, like Rachel Carson, have eloquently reminded us that we don't know how to make a single blade of grass. And St. Matthew, in his wisdom, emphasised that not even Solomon in all his glory was arrayed as the lilies of the field. Faced with such unknowns it is hard not to feel a sense of humility, wonder and awe about our place in the natural order. And to feel this at all stems from that inner heartfelt reason which sometimes despite ourselves is telling us that we are intimately bound up in the mysteries of life and that we don't have all the answers. Perhaps even that we don't have to have all the answers before knowing what we should do in certain circumstances. As Blaise Pascal wrote in the 17th century, 'it is the heart that experiences God, not the reason.'

So do you not feel that, buried deep within each and every one of us, there is an instinctive, heart-felt awareness that provides -if we will allow it to- the most reliable guide as to whether or not our actions are really in the long term interests of our planet and all the life it supports? This awareness, this wisdom of the heart, maybe no more than a faint memory of a distant harmony, rustling like a breeze through the leaves, yet sufficient to remind us that the Earth is unique and that we have a duty to care for it. Wisdom, empathy and compassion have no place in the empirical world yet traditional wisdoms would ask "without them are we truly human?" And it would be a good question. It was Socrates who, when asked for his definition of wisdom, gave as his conclusion, "knowing that you don't know."

In suggesting that we will need to listen rather more to the common sense emanating from our hearts if we are to achieve sustainable development, I'm not suggesting that information gained through scientific investigation is anything other than essential. Far from it. But I believe that we need to restore the balance between the heartfelt reason of instinctive wisdom and the rational insights of scientific analysis. Neither, I believe, is much use on its own. So it is only by employing both the intuitive and the rational halves of our own nature - our hearts and our minds - that we will live up to the sacred trust that has been placed in us by our Creator, - or our "Sustainer", as ancient wisdom referred to the Creator. As Gro Harlem Brundtland has reminded us, sustainable development is not just about the natural world, but about people too. This applies whether we are looking at the vast numbers who lack sufficient food or access to clean water, but also those living in poverty and without work. While there is no doubt that globalisation has brought advantages, it brings dangers too. Without the humility and humanity expressed by Sir John Browne in his notion of the 'connected economy' - an economy which acknowledges the social and environmental context within which it operates - there is the risk that the poorest and the weakest will not only see very little benefit but, worse, they may find that their livelihoods and cultures have been lost.

So if we are serious about sustainable development then we must also remember that the lessons of history are particularly relevant when we start to look further ahead. Of course, in an age when it often seems that nothing can properly be regarded as important unless it can be described as "modern", it is highly dangerous to talk about the lessons of the past. And are those lessons ever taught or understood adequately in an age when to pass on a body of acquired knowledge of this kind is often considered prejudicial to "progress"? Of course our descendants will have scientific and technological expertise beyond our imagining, but will they have the insight or the self- control to use this wisely, having learnt both from our successes and our failures?

They won't, I believe, unless there are increased efforts to develop an approach to education which balances the rational with the intuitive. Without this truly sustainable development is doomed. It will merely become a hollow- sounding mantra that is repeated ad nauseam in order to make us all feel better. Surely, therefore, we need to look towards the creation of greater balance in the way we educate people so that the practical and intuitive wisdom of the past can be blended with the appropriate technology and knowledge of the present to produce the type of practitioner who is acutely aware of both the visible and invisible worlds that inform the entire cosmos. The future will need people who understand that sustainable development is not merely about a series of technical fixes, about redesigning humanity or re-engineering nature in an extension of globalised, industrialisation - but about a re-connection with nature and a profound understanding of the concepts of care that underpin long term stewardship.

Only by rediscovering the essential unity and order of the living and spiritual world - as in the case of organic agriculture or integrated medicine or in the way we build - and by bridging the destructive chasm between cynical secularism and the timelessness of traditional religion, will we avoid the disintegration of our overall environment. Above all, I don't want to see the day when we are rounded upon by our grandchildren and asked accusingly why we didn't listen more carefully to the wisdom of our hearts as well as to the rational analysis of our heads; why we didn't pay more attention to the preservation of bio-diversity and traditional communities or think more clearly about our role as stewards of creation? Taking a cautious approach or achieving balance in life is never as much fun as the alternatives, but that is what sustainable development is all about.

James Naughtie: Your Royal Highness, thank you. Now that phrase 'the living world as one' has been in a way the objective of the five different approaches that we've heard in this year's lectures. So what are the hard choices that need to be made and will they be made? All the lecturers are here. They're all eminent and more to the point, perhaps, they're all in positions of power. They're in places where those decisions must be made. Chris Patten, the European Union's Commissioner for External Relations, Gro Harlem Brundtland, the Director General of the World Health Organisation, Sir John Browne, the Head of BP Amoco, Thomas E. Lovejoy, Chief Biodiversity Advisor for the World Bank and Counsellor to the Smithsonian Institution, and Vandana Shiva, campaigner and Director of the Research Foundation for Science, Technology and Ecology in Delhi. Chris Patten let me ask you first to set our discussion going to take that phrase - 'the living world as one.' It's clear from what you said in your lecture and by general consensus that the language has changed to an extraordinary extent in the last decade or so - people use the language of sustainability and talk about a world as one quite naturally now in a way that they didn't before. What are the dangers of that becoming a piece of political fashion rather than an engine of change in decision making?

Chris Patten: I think considerable. I start with good old St. Matthew and the lilies which I think he went on to say 'neither spin nor do they weave' which is of course true. And life is about value as well as price. I don't think that there has been all that much change in philosophy or approach in the recognition of value over the last few years, even if the language has changed. I think that may have happened at the margins but not very centrally. And secondly, even though I think that policies have in a strictly environmental sense often changed - I mean I remember my days at the Environmental Council in Brussels over a decade ago having to be with other ministers dragged kicking and screaming to accepting more sensible environmental policies. While that to some extent has changed, I think the paradox is that in other areas we've gone backwards, and one of the problems I think that we face today is that globalisation hasn't been accompanied by the rich countries accepting that there is a poor agenda so that we've seen a fall in development assistance to poor countries, with I think a really substantial impact on the environment. So I think some things have actually gone backwards rather than progressed.

James Naughtie: Vandana Shiva, you used the word I think 'smug' while talking about globalisation in your lecture. And that's the point here that we've got to isn't it? - where the issue is whether the language to some degree has become a cover for doing nothing?

Vandana Shiva: Well I don't think it's just a cover for doing nothing - it's a cover for basically doing unjust acts, engaging in non sustainable processes. The idea that rules written by a group of commerce officials are irreversible means that we can never correct our errors. These are not God given, they are not natural phenomena. The rules of commerce and free trade and globalisation are basically rules human beings got together and wrote. There are other rules human beings wrote like the climate change treaty, like the convention on biological diversity which are being marginalised and I think it's time to bring the rules that protect people and the planet at the core of decision making and make commerce derived activity rather than the foundation of our existence.

James Naughtie: So the question John Browne for businessmen like you is whether you can deliver the sorts of changes to which you're personally committed and of which you spoke in your lecture - it's fine to say I believe in these things and I believe we're moving in the direction that will produce real sustainability, but will it happen?

John Browne: I think it will, provided the right time scales are thought through and that in fact rhetoric doesn't overtake the reality of what has to happen on the ground. I think we have to be very authentic in what we say we're going to do - lay it out and then do it and do it again and again. And sometimes the achievements are smaller than people would expect. And therefore they always beg the second question which is, well do more.

James Naughtie: Some people might say that that kind of authenticity is in fact caution is it?

John Browne: No it's not caution. I think it's practicality. And it takes more than ten seconds to figure out what to do - how to, for example, capture CO_2 and re-inject it into deep reservoirs. How to create very minimal disruption to the environment as necessary things are happening - whether that is the discovery of hydrocarbons or the building of homes. These things take time. It's not to say that people are taking all the time. They just have to move as fast as they can and it's not as fast as the words can be spoken.

James Naughtie: But when you go the Amazonian rain forests Tom Lovejoy which you do all the time, do you sense that that process with governments and with businesses is happening fast enough? You talk in your lecture about a spasm of extinction greater than any we've known since the age of the dinosaurs - the polar ice caps starting to melt in 20 years - pretty alarming stuff. Do you think that the thinking through progress if you like is happening at the right pace?

Tom Lovejoy: There are good signs all over the place but you know they're still insufficient to the challenge in front of us. And I guess the reason that I would be optimistic is that when I see humanity confronted with challenges, I often see great creativity arising in response to it and that's exactly the kind of thing we need to be dealing with now.

James Naughtie: What does that creativity mean to you Gro Harlem Brundtland as you look at the tragic cost of poor health across the developing world?

Gro Harlem Brundtland: As Chris Patten was saying here the reduction in attention to development cooperation and the redistribution of funds in the global economy - the fact that that has been sliding back is a tragedy. In the face of all the necessary needs for change it still has happened. However, what we also see now is that civil society, private foundations are coming forward trying to fill part of the gap. Not that that is the only answer, but I just feel that it may add to the awareness in many societies that we need to be sharing because only based on shared values can we move towards sustainability.

Chris Patten: I think the point that's just been made is absolutely fundamental. It's quite extraordinary that during the l990s when admittedly our rhetoric about the environment has become more sustained and developed, when our rhetoric about internationalisation has become more sustained that we've seen a real fall in the amount of assistance which rich countries give to poor countries. And it's not enough to say that is made good by private investment. Private investment doesn't go to the poorest and it doesn't go to the poorest countries. And the sort of figures which you mentioned in your lecture are an affront to our common humanity and they also lead to the real prospect of insecurity - environmental insecurity and political insecurity. And I think it is terribly important to re-establish the moral and the practical, the expedient case in relation to the environment, in relation to our political stability of good old fashioned development assistance - spending money on people, on their health, on their education as well as on their environment.

Vandana Shiva: I think part of the problem that needs to be addressed at this millennium threshold is that there are new ways being found of draining the last resources of the poor - and no matter how much development assistance is given, even if it's brought back to the older levels - if meantime you have patents on seeds, you have patents on plants and medicine which will increase the debt burden of the third world countries ten fold just to pay royalties for knowledge and biodiversity that was theirs in the first place. You've got a mechanism for creating poverty.

James Naughtie: How do you challenge that mechanism politically?

Vandana Shiva: I think you need to challenge it by challenging the models of intellectual property rights that have been enshrined into the World Trade Organisation, that are implemented through the trade related intellectual property which all third world governments, all of Africa, India, Central America are saying these need to be re-written. These laws are not suitable to governing a world for justice and sustainability. We really need to revise those norms.

James Naughtie: Tom Lovejoy you've talked about sustainable development as a theory and as a way of life for a very long time now. You're working with the World Bank at the moment. Now the World Bank is seen by many people who'd agree with Vandana Shiva's point as somehow an agent of these practices which is making things worse not better. Why can you say that it isn't?

Tom Lovejoy: Well I mean the World Bank is sort of a mix like any government, any country - I mean there are a lot of good things that go on and there are a lot of shall we say 'old fashioned' things that go on. But the point I really wanted to make is I have an uncomfortable feeling about the wave of prosperity that we've had in the United States in particular - not just because it doesn't seem to be accompanied by greater generosity in overseas assistance, but it's sort of leading to inward looking tendencies and more consumption instead of taking advantage of it to do good.

James Naughtie: John Browne you were nodding there. Do you think that prosperity means that the sense of urgency is dulled?

John Browne: I think it's a matter of understanding where the power actually lies. The reality is that however again in my experience business is done in the world it is inter connected. Trade has always been around and it remains the vital fundamental of business. So to say that everything could be done inside a country and that you're fine and everyone else isn't is I think to sign a very bad certificate for the future I would say. I think that the connectivity of the world that we now have where people can understand what's going on anywhere at anytime simply makes it more difficult to sustain that position.

James Naughtie: And yet Chris Patten when you sit in the Commission in Brussels you can be accused by outsiders as being part of a great sort of lumbering machine which acknowledges that things can't be done in one country and yet to many outsiders seems to have failed in vital areas like agriculture, producing an agriculture policy that makes sense over many decades and all the rest of it. It's seen as wasteful and inefficient isn't it? And do you see it as wasteful and inefficient - at least in its past incarnation?

Chris Patten: Well I see some - I see some of its manifestations - let me be careful in how I put this as less than desirable. But I want to make a point about international organisations whether, it's not a very adequate description of the European Union, whether the European Union or the WTO or the World Bank - we all know that the nation state remains the basic political unit, but we also know that everybody recognises that because of global trends, more has to be determined on a regional, international, global level, so we set up these organisations which, alas, haven't yet found a way of commanding the loyalty which people feel towards national institutions. Now I want to speak up for the poor old World Bank. I actually think that the World Bank has probably done more than any other global organisation to recognise the new world we're living in, to recognise the importance of the environment and of social issues, and the consequence of the sort of demonstrations that we've seen against the World Bank is that the World Bank will get fewer resources to spend in poor countries because of it being discredited in Washington bang next door to Capitol Hill. This is the awful paradox - here is an organisation which reflects the importance of transfers from rich to poor, which reflects the importance of having international rules. The World Bank which is on the side of the poor has I think been - and on the side of a better environment - has I think been extremely unfairly criticised.

Vandana Shiva: When the World Bank and IMF actually go for replenishments - they lay out figures and say that for every dollar they put into poor countries they make three dollars for the rich countries and that's the justification which keeps them running. My own lifetime of being an environmental researcher and campaigner has brought me against project aid after project aid from the World Bank, that has devastated our people and our eco systems. The entire conversion of our rich forest biodiveristy into eucalyptus mono culture is financed by the Bank, the destruction of the mangroves along our coasts leading to huge cyclone damage, salinity for coastal areas financed by the Bank for industrial shrimp farming, the erosion of our genetic diversity in agriculture financed by the Bank for the green revolution - the list is absolutely endless, and in fact if the World Bank is an issue for northern environmentalists and northern campaigners it's because movements of hundreds and thousands of tribals and peasants in the Third World have talked about the threat to their very survival.

James Naughtie: If we accept that globalisation in some form is here, can't be wished away, is going to continue - what are the changes that you would like to see in the way that the global economy is encouraged and managed if you like that would avoid that kind of disaster as you would see it?

Vandana Shiva: Well you know when it's made to look like it's the first time we're doing international trade I keep thinking of all the pepper from India that brought the British and got Columbus sailing in the wrong direction, claiming he'd discovered North America. We've had international trade before. We've had rules of international trade before. We've also had free trade rules before which in my view lead to the Bengal famine of '42 and I think what we need to do is allow countries to restrict exports and imports if the environment requires it and if public health requires it and if livelihood protection requires it. We'll have to put that freedom of countries back on the agenda, because on it is based the freedom of people.

James Naughtie: Gro Harlem Brundtland you made the point that slum clearance in the 19th century happened when it was in the interests of society to stop it developing. You talked about us all swimming in the same sea, sharing the same diseases if you like, to put it crudely, around the world. Is that the kind of incentive that is going to produce real change?

Gro Harlem Brundtland: Well I hope so. It's one I think strong argument about why we are in this together. And the fact that in European countries historically they dealt with what was next door - the things they saw and understood and they made changes in the policy directions which improved the quality of life and the quality of societies. But they didn't go far enough to look at it around the globe and to see the same problem far away in the colonial parts.

James Naughtie: You argue that at one point in our history governments tended to look on the developing world, on health as a luxury that came after basic economic development, and you're arguing well, that's not what it is at all. If you produce better health then you will get poverty down. Is it the sort of idea that the governments with whom you deal understand and are willing to act upon?

Gro Harlem Brundtland: Increasingly, I see that it's happening. Several governments are now aware that it is not wise to let human capital, even in, you know, said in those terms, let it down and sink into poverty instead of, for instance, giving all children vaccines. Now 30 million children don't get vaccinated with basic, simple technologies that all of us in our countries take for granted. Three million die because they don't get those quite cheap vaccines at the time in life when they need it, and of course families keep getting more children, families feel that they cannot depend on their children growing up, and it adds to the total burden of people feeling incapacitated and disempowered. So why are we not able to vaccinate every child? I use it as an example. Why is that not an obligation to all of us as it is in our own countries? We wouldn't dream of not being able to vaccinate all our own children wherever they live.

James Naughtie: You talked about human security in the United States being as important now as national security - a very striking phrase. Do you think people believe that, or have yet understood it assuming that it's true?

Gro Harlem Brundtland: Well there is a debate going on which I believe can be brought forward about that issue.

James Naughtie: ... Chris Patten's shaking his head there...

Chris Patten: Well the focus in the United States is on investing in spectacular out of space technology in order to protect the United States from the insecurity of the world in the 21st century. Whether or not that's a sensible approach, for most of us geography renders that simply impossible, and the only way you can actually deal with insecurity is by trying to invest in people's prosperity and in their stability. And a point which I think the Prince of Wales was getting at earlier and which has been touched on in this discussion is the extent to which what is right is also what's expedient. But it's actually in our interest to invest in peoples' health and this isn't a great breakthrough discovery - as the Asian development bank has pointed out, one of the reasons for East Asia's spectacular success was of course land reform, was of course opening or believing in leaving business to businessmen, but was also investing in people, in their basic health and basic education. And the extraordinary improvements in literacy rates, in child mortality statistics and so on in East Asia was one of the reasons for economic take off there. I think the point about vaccines and ill health in developing countries, which is of course related to environmental issues, I think that reflect on what we were saying earlier about the rich countries' agenda. Take pharmaceutical companies - there's no difficulty in getting pharmaceutical companies to invest in - in the ailments of the rich, in baldness and impotence, in their heart disease - but get them to invest in malaria - a vaccine against malaria - 80 million only a year being spent on that. Jeffrey Sachs from Harvard has suggested all sorts of market mechanisms for increasing that, but it kills malaria I think what - 2.5 million people every year?

James Naughtie: Right John Browne - you're a businessman, how do you do that? - you don't make pharmaceuticals but ...in this game... how do you get companies to understand the interests in that kind of investment which to many of them it seems is less obviously a good investment than what they do at the moment?

John Browne: I think it is the case not just in pharmaceuticals but in a lot of activity where the full value of the activity has to be exposed very transparently...

James Naughtie: By whom?

John Browne: Oh by both the business people and the government. There's always a sharing of rent - in one way or another between government and a business and that I think is something we shouldn't forget because many people think business just comes in, does something and leaves. In my business that's the last thing we can do. We're actually there for hundreds of years and therefore we must strike a balance of who gets what part of the rent distribution? Because when you think of all the things involved then I think you'll get the equation right.

Chris Patten: Companies invest in slow ripening tomatoes because they think there's money in it.

Vandana Shiva: They didn't make any money......

Chris Patten: And they invest - and they invest - they invest in baldness rather than malaria because they think there's money in that. I think that governments can actually help to shape the market. First of all, by making the real costs of things apparent - the externalities as economists call them, but secondly by actually offering inducements and the idea that Jeffrey Sachs of Harvard has put forward in relation to malaria is the rich countries, the rich governments should be actually giving a guarantee to pay for each vaccine which is used against malaria which will then stimulate the private sector to do the research and development of the drug which is necessary.

John Browne: The tools and techniques are well known. They're to do with taxation, to do with market instruments - all these sorts of things and they really do work. If you take the case of the environment you know you could pass thousands of regulations to do with reducing carbon dioxide emissions. But actually if you just get to trade permits you have an extraordinary way of clearing the market, letting people get on with things and actually getting a result.

James Naughtie: What precisely are we talking about? - let's get practical about this - what do you want to see - Tom?

Tom Lovejoy: Well in the short term - a corporation that is facing some activity they want to get into which will release CO2 paying for a CO2 off set elsewhere in the world - wherever that market may be.

James Naughtie: We're talking in a way about punitive taxes aren't we - are we John Browne?

John Browne: No we're not. We're talking about a balance of incentives. I mean there's always a carrot, and there's always the stick - there must be that. There must also be enforcement and transparency.

James Naughtie: You're happy to see a bigger stick?

John Browne: Oh - I'm very happy to see transparency and fair play.

James Naughtie: But what do governments do and what do societies do about businesses which aren't enlightened, and aren't behaving in the way that in the best of all possible worlds you hope they do?

John Browne: Well I think no business wants to have a free loader around - someone who takes advantage of the system. So I think in today's practical terms - first, there's a huge demand for transparency, so say what you're going to do, and then report against what you have said so that keeps going well. Secondly, market based mechanisms where people who break the rules have to pay a tremendous amount of money. And finally, enforcement. I think that's important - I mean it is the contract with society that is expressed by the role of government here as the enforcer.

James Naughtie: Vandana Shiva can a mixture of market mechanisms and enforcement produce what you want?

Vandana Shiva: I think the parts that we constantly forget is people in society and it's not just government acting through business and regulations on business, but governments empowering, defending the rights of people, ensuring small farmers are able to stay on land, practice organic farming, that public health is a universal right for all, that food access and entitlements is a global right - that that defence of rights of people is the biggest obligation of governments and we can't always mediate those rights via the market and by purchasing power because large number of poor who do not have purchasing power cannot get their entitlements through the market, and I think it's the exclusion of those rights and the exclusion of the government functions in the defence of those rights that has been the big sacrifice in globalisation. We need to reintroduce that debate.

Gro Harlem Brundtland: I think it's a difficult call to find the exact balance given what you're just saying. And as the world is negotiating in different areas, not only in commerce as you talked about earlier on WTO, but on biodiversity, on climate convention, and looking for solutions which can work across the board. I think that process has to continue, but one has to take into greater account and take into the balance more of what you're saying than what has been the case until now - because some of the rich countries who are dominating negotiations have had the ability to make definitions about how they take care of all parts of their societies, and then they negotiate and have a stronger negotiating power than smaller countries or poorer countries, so the balance is not right. And that is also what you are reacting to.

James Naughtie: You said in your lecture that the world should learn to look at itself through the eyes of the poor - I think I more or less quote you accurately there - now do you really believe in a world of vast transfers of money across borders, enormous explosions of wealth in the developed world - that that is happening or will happen?

Gro Harlem Brundtland: Well it is happening and our ability in our democracies to take care of those who need to be taken care of with their rights, with their human rights, with their place in society, that has to be increased. But when we talked earlier about the climate convention and the permits and the exchange of rights or duties with regard to emission of CO2, I don't think that there would be real disagreement around this table that that must be in that case the way to go.

James Naughtie: You talked Chris Patten about the importance of government being inclusive perhaps more outward looking than it's been in the western world in the past as a means of meeting that challenge. Do you think that it is happening? I mean we've just heard from Gro Harlem Brundtland that she believes in many respects there is a profound change in peoples' attitude beginning to appear. Do you share that view?

Chris Patten: I'm not sure that governments and traditional political structures have yet found a way of coping with entering a proper and comprehensive dialogue with present manifestations of civil society which aren't always candidly very democratic. I mean they're sometimes democratic, but not always. It is a very curious world that we live in - in which NGOs are often very much better resourced for example than UN bodies or UN institutions.

James Naughtie: The non-governmental organisations who work in so many fields .....?

Chris Patten: Absolutely - you see it in the human rights field. You see it in the environmental field as well. And I don't think one should always begin from the assumption that the government democratically elected or the international organisation which is very often a combination of the political efforts of democratically elected governments is wrong and the NGOs are right. I think we have to develop a much more open dialogue between them if we want to have the changes in society and the changes in political attitudes which we began by discussing.

James Naughtie: But you see Tom Lovejoy you have some fairly practical suggestions here. I mean you talk for example - let's have some biodiverse areas around the world - very specific - Los Angeles you know - somewhere in South America, somewhere in the Indian sub continent which is a pretty startling thought, which most governments would say - oh well lovely idea, great to hear it in a Reith lecture but it will never happen. Can something like that occur and is that the kind of spark without which this just remains academic talk?

Tom Lovejoy: Well I mean first of all some of it is happening - a surprising amount is happening - like a middle American biological corridor from Mexico all the way to Columbia. It is of course not enough. I think the really important thing is what comes down to happen in particular places. And if I think about the Amazon for example - there is no solution to the Amazon problem until the 20 million people living there have an adequate quality of life, and that's what we have to sort of join all the different sectors together to address.

James Naughtie: Well let me quote two of your experiences to you - when you delivered your lecture in Los Angeles it was pretty clear afterwards in the questioning that some people said - well fine but don't ask me to give up my car. And then you take American senators regularly and congressmen down to the Amazon and you say here is the situation - here is what we have to tackle. Now how do you cope with the senator's reaction who says well this is fine, and I see the enormity of what you point to me, but back home they're not going to give up their car?

Tom Lovejoy: Well I mean actually the interesting thing is that the senators I've taken down are very good about all of this - it's the one who - the ones who haven't gone I worry about. And that's not just a problem of the particular elected officials although I think there is always a big lag time between who's holding office and public opinion. I don't think public opinion is strong enough in the United States yet. I don't think they get the sense of urgency.

Chris Patten: It's always been the most difficult task of political democratic leadership to convince people that something which seems to be painful or involving sacrifice in the short term is actually best for them in the medium or long term, and the excitement of democratic politics is that it should enable you to mobilise opinion in that sort of way. I'm not sure perhaps we see enough of that just at the moment.

James Naughtie: What you are referring to is what we often call leadership isn't it?

Chris Patten: It's what we call leadership rather than focus groups - rather than going to a focus group to discover not just what you want to say but how to say it.

John Browne: It brings us back to...

James Naughtie: John Browne yes...

John Browne: The tools and techniques are available - I agree with you - governments do have to take a real position of policy in leadership in amongst all this noise and debate. It's valid - but the NGOs, business, many sectors of society - I think to opt out is really to give a very strange result to this where the voice of the few will direct the actions of the many and that I think is a problem.

James Naughtie: Let me try to be practical here, because if we're talking about leadership you are all leaders in your organisations, and in a sense in the opinions that you're generating and discussing in these lectures and this discussion and let me ask you how we put flesh on the bones of this - we've heard the Prince of Wales talking passionately about the need to understand how people and progress are different sides of the same coin, how the Earth is still a sacred trust - wherever you come from on the religious or moral spectrum. Now how do we put together the enormity of such thoughts with the practical business of day to day life - in politics, in business, in organisations which are trying to tackle seemingly insoluble problems of health - in practical terms what do you all do in the next five years? - Gro Harlem Brundtland?

Gro Harlem Brundtland: Well I was thinking of the summit in Nigeria that I just came from where 20 African leaders came together for 2 days, really going into in great detail the problem of malaria. On that continent 3 hundred million people are sick every year and it undermines the future, the economic potential, the human potential and it creates insecurity for life. Now if you don't get to the government leaders in dealing with basic human concerns like this, and it's linked to the environment, there is no way I think forward. If they don't focus on these issues as basic social and environmental concerns how can they lead their countries into the future? We see ourselves as supporting those kinds of actions. In practical terms - getting bed nets to every African child in every country where their life is threatened by malaria.

James Naughtie: There we have an action plan - John Browne what's yours?

John Browne: I don't want to sound too programmatic but I think you can break it down into a programme. The first and most important thing I think is that for the leadership of any enterprise, commercial enterprise, the leadership itself needs to be educated and experienced. People must see with their own eyes what is actually going on in Bombay, Azerbaijan, Algeria . It doesn't matter where. You have to go to go to see and you must talk to people and you need to understand what it means and therefore a sense of educative presence I think, an experienced presence is critical. Secondly I think then deciding what to do, saying what you're going to do and reporting against it and making it part of everyday life. This is not something which is separate and apart from making money, or educating - or developing your staff. It's one and the same thing. It's part of everyday experience - how do we clean up the water a little bit, how do we make sure less CO_2, how can we ... how can we develop one more person to give them an idea of what the promise of the future is. These things are day to day, but they're all to do with delivering a business result.

James Naughtie: Tom Lovejoy you gave an alarming picture of the kinds of disasters that might lie around the corner if we don't get this right. In practical terms how do we get it right?

Tom Lovejoy: Well I think it sort of breaks down into almost two distinct but related issues - one is climate change and I think we've dealt with that. We just simply can't allow CO_2 to accumulate to two, three even more times on our pre industrial levels, and things can be done in terms of carbon trading and new technologies like hydrogen fuel cells. But the other really comes down to biodiveristy and what happens in landscapes. And that only can be addressed properly if - if all the elements represented by the other Reith lecturers have brought together with those who are worried about the details of the biology.

James Naughtie: We've had many comments by e-mail and by more traditional means during the course of the lectures about what's been said, and many people are arguing that there is a willingness to accept some short term pain given the enormity of the issues that we face. Do you believe that's true or are the sort of people who write e-mails like that the people who've always believed that anyway - the goodies?

Tom Lovejoy: Well looking at a couple of the examples I used in my own Reith lecture, I think it turns out that the pain was less than people thought. That was the good news in those particular examples. And maybe I'm being a little optimistic here but I would view those as at least partial success stories.

James Naughtie: Vandana Shiva, looking ahead what are the practical things that you want to see to move towards the kind of sustained world that everyone is talking about in different ways?

Vandana Shiva: Most immediately what I work towards and what I'd like to see is the possibility that small farms in every country, north and south, rich and poor are able to survive into the future with sustainable methods - that that becomes a reality and to make that reality happen we will need to change the rules of trade, national agricultural policies - we'll have to rewrite the agreement on agriculture in the WTO - centre more on sustainability and small farm survival - then on maximising the profits of five grain traders in the world. I want to see farmers everywhere have the inviolable right to save seed because seed is sacred. It's their duty to save it and that would mean changes in the intellectual property rights laws world-wide, to exempt and exclude life forms from patentability because life as his Royal Highness mentioned is sacred. It's not a human engineered invention. It is the very symbol and embodiment of creation and its continuity.

James Naughtie: Do you see that threatened by the genetically modified organisms that are beginning to....?

Vandana Shiva: Very, very seriously and I think we now have more than enough evidence that the idea that genetic engineering is an imperative because without it people will starve - it's not at all true. Organic production increases food production many fold. It sustains biodiversity, protects the Earth, and protects all farmers while bringing us good food. And I think it's time that at least 50 percent of the world's money was put into research on organic methods and improvement of indigenous methods rather than this blind investment only in genetic engineering whose hazards are known, whose counter productivity is now established and which increases monopoly controls which we can't afford.

James Naughtie: So finally Chris Patten, a practising politician and I suppose in Brussels you feel like Sisyphus pushing his rock up the hill - it's always about to come down and crush you. How do you succeed in the task that's a shared objective by everybody here to make a difference?

Chris Patten: I think you have to believe that people are capable of being and doing better. I think the words that were used earlier - reverence and awe and value are all important and I think it should be much more part of our political debate and to talk about the morality of issues and the combination of morality and expedience. I think one has to challenge people with the fact for example that today we spend what 11 billion Euros, dollars in Europe on ice cream which is about twice what it would cost to provide access to clean drinking water for people in poor countries. I think those sort of moral affronts are things that people have to be challenged with and I don't despair of being able to lift peoples' eyes beyond the GDP figures to a rather more important horizon.

James Naughtie: Thank you all very much - Chris Patten, Gro Harlem Brundtland, Tom Lovejoy, John Browne and Vandana Shiva. Perhaps we should all meet again in 10 years or so and see how far we have got. Thank you very much indeed to all our Reith lecturers here. Thank you to all of you who've been sending comments to us as it's gone on. We hope that those continue. Thank you also to our host here at Highgrove - his Royal Highness, the Prince of Wales for his own thoughts on sustainable development. Now from me, James Naughtie, and this year's Reith lecturers, good night.

November 7, 2005

Edge 172
11.1.2005
(2,800 words)

THE $100,000 EDGE OF COMPUTATION SCIENCE PRIZE

The Nominations

IN THE NEWS

"Is science driven by inspired guesswork?"

Ian McEwan, author of *Saturday* — Exceprted from *The Telegraph*

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Is science driven by inspired guesswork?

History abounds with examples of how instinct, not data, led to discoveries. Even Einstein's theory of relativity had to wait decades for verification, says Ian McEwan

...This collection, mostly written by working scientists, does not represent the antithesis of science. These are not simply the unbuttoned musings of professionals on their day off. The contributions, ranging across many disparate fields, express the spirit of a scientific consciousness at its best - informed guesswork that is open-minded, free-ranging, intellectually playful.

Many replies offer versions of the future in various fields of study. Those readers educated in the humanities, accustomed to the pessimism that is generally supposed to be the mark of a true intellectual, will be struck by the optimistic tone. Some, like the psychologist Martin Seligman, believe we are not rotten to the core. Others even seem to think that the human lot could improve.

Generally evident is an unadorned pleasure in curiosity, a collective expression of wonder at the living and inanimate world which does not have an obvious equivalent in, say, cultural studies. In the arts, perhaps lyric poetry would be a kind of happy parallel.... [click here to continue]

The Edge Dinner

"Open-minded, free-ranging, intellectually playful ...an unadorned pleasure in curiosity, a collective expression of wonder at the living and inanimate world ... an ongoing and thrillingcolloquium." — Ian McEwan, Author of *Saturday*

THE $100,00 EDGE OF COMPUTATION SCIENCE PRIZE
[10.28.05]

no.54
"What scientists believe but cannot yet prove"
(cover story)

THAT FAMOUS EQUATION AND YOU
by Brian Greene
[10.6.05]

THE VAGARIES OF THE RELIGIOUS EXPERIENCE
by Daniel Gilbert
[9.28.05]

THE $100,000 EDGE OF COMPUTATION SCIENCE PRIZE

For individual scientific work, extending the computational idea, performed, published, or newly applied within the past ten years.

The Edge of Computation Science Prize, established by Edge Foundation, Inc., is a $100,000 prize initiated and funded by science philanthropist Jeffrey Epstein.

The list of nominees are being announced today, Tuesday, November 1st, at Festival della Scienza 2005 in Genoa and simultaneously on *Edge*. The judging will take place on Tuesday-Wednesday, November 8th & 9th, and the winner will be announced on this page on Thursday. November 11th.

The nominees for the first Edge of Computation Science Prize are...

[...continue]

TURING'S CATHEDRAL [10.24.05]
A visit to Google on the occasion of the 60th anniversary of John von Neumann's proposal for a digital computer
By George Dyson

My visit to Google? Despite the whimsical furniture and other toys, I felt I was entering a 14th-century cathedral — not in the 14th century but in the 12th century, while it was being built. Everyone was busy carving one stone here and another stone there, with some invisible architect getting everything to fit. The mood was playful, yet there was a palpable reverence in the air. "We are not scanning all those books to be read by people," explained one of my hosts after my talk. "We are scanning them to be read by an AI."

[...continue]

THE OPIATES OF THE MIDDLE CLASSES
by Nassim Taleb
[9.28.05]

DANGLING PARTICLES
by Lisa Randall
[9.19.05]

THE MOUSTRAP
by John Allen Paulos
[9.10.05]

WHO DESIGNED THE DESIGNER?
Marcelo Gleiser
[9.4.05]

THE CASE AGAINST INTELLIGENT DESIGN
Jerry Coyne
[9.1.05]

ONE SIDE CAN BE WRONG
Richard Dawkins & Jerry Coyne
[9.1.05]

UNINTELLIGENT DESIGN
Scott Atran
[8.30.05]

SHOW ME THE SCIENCE
Daniel C. Dennett
[8.29.05]

IN DEFENSE OF COMMON SENSE
John Horgan
[8.15.05]

A MADMAN DREAMS OF TURING MACHINES
Janna Levin
[8.15.05]

Genoa, october 27 - november 8, 2005

George B. Dyson & J. Craig Venter

Festival della Scienza 2005 (October 27 - November 8), under the direction of Vittorio Bo, will present leading third culture intellectuals (including numerous *Edgies*), who are pushing the frontiers of science. Participants include geneticist Luigi Luca Cavalli Sforza, science historian George Dyson, archaeologist Brian Fagan, paleontologist Richard Fortey, physicist Neil Gershenfeld, string theorist Brian Greene, physicist Robert Laughlin, mathematician Benoit Mandelbrot, zoologist Desomond Morris, mathematical physicist Roger Penrose, cosmologist Martin Rees, Merrott ruhlen, biologist Steven Rose, theoretical physicist Gino Segre, physicist John Stachel, paleontologist Tattersall, genomics researcher Craig Venter, among others, and includes influential journalists such as Alun Anderson *(New Scientist*) and Armando Massarenti (*Il Sole 24 Ore*). [Click here for a PDF file of the programme].

GÖDEL AND THE NATURE OF MATHEMATICAL TRUTH II
Verena Huber-Dyson
[7.27.05]

"SPIDERS"
Katinka Matson
[7.27.05]

AN EPIDEMIOLOGY OF REPRESENTATIONS
A Talk with Dan Sperber
[7.27.05]

EDGE SUMMER BOOKS
[7.12.05]

BIOCOMPUTATION
J. Craig Venter, Ray Kurzweil, Rodney Brooks
[6.29.05]

GÖDEL AND THE NATURE OF MATHEMATICAL TRUTH
A Talk with Rebecca Goldstein
[6.8.05]

THE SCIENCE OF GENDER AND SCIENCE
Pinker vs.Spelke
A Debate
[5.10.05]

John Gottman
THE MATHEMATICS OF LOVE
[4.14.05]

Simon Baron-Cohen
THE ASSORTATIVE MATING THEORY
[4.3.05]

JB

All roads lead to Genoa for one of the world's leading third culture events.

NOW IN PRINT! **"Fantastically stimulating...Once you start, you can't stop thinking about that question. It's like the crack cocaine of the thinking world. " — BBC Radio 4**

What We Believe But Cannot Prove: Science in the Age of Certainty
John Brockman (Editor)
Introduction by Ian McEwan

"What do you believe is true even though you cannot prove it?" This was the question posed by John Brockman to a group of leading scientists and thinkers via his Edge.org website. The subsequent answers created a media storm and prompted a fiery debate about all aspects of science, technology and even the nature of "proof". "What We Believe But Cannot Prove" brings together the very best answers from the most eminent contributors. Here is Ian McEwan on the absence of an afterlife; Richard Dawkins on the relationship between design and evolution; and Jared Diamond on when humans first reached the Americas. Other contributions from luminaries like Steven Pinker, John Horgan and Martin Rees span the whole range of scientific endeavour and human experience, from the future of computing to the origins of intelligence; from insights into childhood behaviour to cutting-edge cosmology. Thought-provoking and hugely compelling, this collection is both a fascinating insight into the instinctive beliefs of some of the most brilliant minds alive today - and an invitation to answer the question yourself...

UK: Free Press (Hardcover); US: HarperCollins (Paperback original); forthcoming: March, 2006

IN FORMA LA MENTE no. 54
QUARK
(Cover Story)
[...click here for 9-page 4-color story pdf]

What scientists believe but cannot yet prove

Time, space, aliens, and God...the views of 18 great minds give their answers

THE SCIENCE OF THE FUTURE

Testi di Riccardo Oldani
Illustrazioni di Mario Taddei
Ed Eduoardo Zanon/STUDIODDM

[click here to enlarge cover]

Katinka Matson
NEW IMAGE FOR THE NEW YEAR
[1.4.05]

2004

Benoit Mandelbrot
A THEORY OF ROUGHNESS
[12.20.04]

Karl Sigmund
INDIRECT RECIPROCITY, ASSESSMENT HARDWIRING, AND REPUTATION
[12.6.04]

Gregory Bateson: The Centennial
AFTER BATESON
by John Brockman with an Afterword by Gregory Bateson
[11.20.04]

Robert Trivers: An *Edge* Special Event
A FULL-FORCE STORM WITH GALE WINDS BLOWING
[10.18.04]

V.S. Ramachandran:
THE ASTONISHING FRANCIS CRICK
[10.18.04]

SUMMER POSTCARDS - 2004
[10.4.04]

Smolin vs. Susskind:
THE ANTHROPIC PRINCIPLE
[8.17.04]

Richard Dawkins
TOPS PROSPECT'S LIST OF BRITAIN'S 100 TOP PUBLIC

THAT FAMOUS EQUATION AND YOU [10.6.05]
by Brian Greene

Einstein's derivation of $E = mc^2$ was wholly mathematical. I know his derivation, as does just about anyone who has taken a course in modern physics. Nevertheless, I consider my understanding of a result incomplete if I rely solely on the math. Instead, I've found that thorough understanding requires a mental image - an analogy or a story - that may sacrifice some precision but captures the essence of the result.

Here's a story for $E = mc^2$. Two equally strong and skilled jousters, riding identical horses and gripping identical (blunt) lances, head toward each other at an identical speed. As they pass, each thrusts his lance across his breastplate toward his opponent, slamming blunt end into blunt end. Because they're equally matched, neither lance pushes farther than the other, and so the referee calls it a draw.

This story contains the essence of Einstein's discovery. Let me explain.

[Editor's Note: First published as an Op-Ed Page article in *The New York Times* on Friday, September 30th]

[...continue]

THE REAL CRISIS IN EVOLUTION TEACHING [9.29.05]
By Scott D. Sampson

Efforts to educate children and the general public about biological evolution have long suffered a severe crisis of relevancy independent of religious influences, and this crisis continues unabated. Even for those who accept its veracity in this country and others, evolution is generally (and mistakenly) envisioned as a process of the past, encompassed by abstract concepts that have little bearing on humans, let alone the future of Earth's diversity. This failure of education, while complicated by a number of factors, is due in large part to a lengthy history of fragmentation and compartmentalization within academia that has left us with a void between two fundamental ideas: ecology and evolution.

[...continue]

EFFECTIVE FORECASTING ...OR...THE BIG WOMBASSA
[2.13.04]

Gary Marcus
LANGUAGE, BIOLOGY, AND THE MIND
[1.28.04]

Stewart Brand
THE MOUNTAIN AND THE CLOCK
[1.18.04]

Edge 7th Anniversary: A Photo Album
[1.12.04]

The World Question Center - 2004 [1.12.04]

WHAT'S YOUR LAW?

Katinka Matson
Print Editions
[1.12.04]

more

The Prospect/FP Top 100 Public Intellectuals [9.28.05]

Over the summer, *Edge* heard from David Goodhart, editor of *Prospect* magazine, with regard to involving the *Edge* network in a follow-up event to *Prospect*'s poll last year of the top 100 public intellectuals in Britain (see "Richard Dawkins Tops *Prospect's* List of Britain's Top Public Intellectuals")...

> "Following the success of our 100 top British (or Britain-based) public intellectuals last year — we are drawing up a list of the top 100 *Global* public intellectuals (living ones) and ask readers to pick the top ten.
>
> "At worst this kind of thing is harmless fun — at best it even gets people thinking a bit about trends in modern thought. As with the British version we are not drawing up a rigorous definition of public intellectual — nor of global.
>
> *Prospect* is a London-based publication and we see the world from here, that will obviously effect our selection, but we want a list that captures the important thinkers in all the big disciplines and centres of population.
>
> "I am interested in enlisting selected members of the *Edge* network — people that you would consider to be "global brains-trusters" — and asking for help in drawing up that initial list of 100.
>
> "I would very much appreciate you sending this email out and asking people if they can spare a few minutes and please note down their top 20 (or more if you can spare a bit more time). Thanks for your help.
>
> David Goodhart (editor, *Prospect*)

Prospect has joined forces with America's *Foreign Policy* magazine to compile the list which has just been released.

One can assume the Edgies responded since more than 10% of the Global 100 are regular *Edge* contributors and third culture intellectuals such as Richard Dawkins, Daniel C. Dennett, Jared Diamond, Freeman Dyson, Howard Gardner, Neil Gershenfeld, Jaron Lanier, Steven Pinker, Martin Rees, Craig Venter, and E.O. Wilson. Others on the eclectic list include Ali Al-Sistani, Pope Benedict XVI, Hans Küng, and Paul Wolfowitz.

Click here to view the selection and to vote for your own top five from the list.

ledge...a website that will expand your mind."

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"Awesome indie newsletter with brilliant contributors."

"Everything is permitted, and nothing is excluded from this intellectual game."

[...continue]

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"...Thoughtful and

[*THE VAGARIES OF RELIGIOUS EXPERIENCE*](#) [9.28.05]
By Daniel Gilbert

Is God is nothing more than an attempt to explain order and good fortune by those who do not understand the mathematics of chance, the principles of self-organizing systems, or the psychology of the human mind? When the study I just described was accepted for publication, I recall asking one of my collaborators, who is a deeply religious man, how he felt about having demonstrated that people can misattribute the products of their own minds to powerful external agents. He said, "I feel fine. After all, God doesn't want us to confuse our miracles with his."

That's fair enough. Science rules out the most cartoonish versions of God by debunking specific claims about ancient civilizations in North America or the creatio ex nihilo of human life. But it cannot tell us whether there is a force or entity or idea beyond our ken that deserves to be known as God. What we can say is that the universe is a complex place, that events within it often seem to turn out for the best, and that neither of these facts requires an explanation beyond our own skins.

[...continue]

[*THE OPIATES OF THE MIDDLE CLASSES*](#) [9.28.05]
By Nassim Taleb

We humans are naturally gullible — disbelieving requires an extraordinary expenditure of energy. It is a limited resource. I suggest ranking the skepticism by its consequences on our lives. True, the dangers of organized religion used to be there — but they have been gradually replaced with considerably ruthless and unintrospective social-science ideology.

[...continue]

DANGLING PARTICLES [9.19.05]
By Lisa Randall

The very different uses of the word "theory" provide a field day for advocates of "intelligent design." By conflating a scientific theory with the colloquial use of the word, creationists instantly diminish the significance of science in general and evolution's supporting scientific evidence in particular. Admittedly, the debate is complicated by the less precise nature of evolutionary theory and our inability to perform experiments to test the progression of a particular species. Moreover, evolution is by no means a complete theory. We have yet to learn how the initial conditions for evolution came about — why we have 23 pairs of chromosomes and at which level evolution operates are only two of the things we don't understand. But such gaps should serve as incentives for questions and further scientific advances, not for abandoning the scientific enterprise.

This debate might be tamed if scientists clearly acknowledged both the successes and limitations of the current theory, so that the indisputable elements are clearly isolated. But skeptics have to acknowledge that the way to progress is by scientifically addressing the missing elements, not by ignoring evidence. The current controversy over what to teach is just embarrassing.

[Editor's Note: First published as an Op-Ed Page article in *The New York Times* on Sunday, September 18th]

[...continue]

Roger Schank

Distinguished Career Professor at the School of Computer Science, Carnegie-Mellon University; Author, *Virtual Learning*.

The debate between those who believe in evolution and those who believe in “intelligent design” is always formulated in terms of what we should teach our children. Some say both theories. Some say only one.

Here is what we should teach our children: nothing, none of it.

Keep your theories. Teaching theories to children is just so much indoctrination. Debates about which theory to teach are just debates about power, they are not debates about education.

Here is what we should teach our children: how to think; how to look at evidence and determine reasonable conclusions that can be derived from the evidence; how to know what constitutes evidence; how to interpret evidence.

Stop telling children facts. Do that in church or wherever religious indoctrination takes place. School should not be about indoctrination but reasoned thought. Teach children to come to their own conclusions. Stop confusing religion with thought.

Ernst Pöppel

Brain researcher; Director, Institute for Medical Psychology, University of Munich.

I think, that the discussion on "intelligent design" suffers from one problem on the scientific side. I have learned in school, that we have to distinguish between different causes. Aristotle distinguishes 4 such modes, namely causa materialis, causa formalis, causa efficiens and causa finalis.

The last mode is in biology of greatest importance, i.e. that functions serve a certain purpose. We understand evolution only if we take seriously this mode of causality. If we as biologist, don't use this certainly not new arguments of purpose, also a driving force for evolutionary processes, we are in a weak position. Not everything can be explained on the basis of "causa materialis". Thus, back to Aristotle and the differentiation of causes.

THE MOUSETRAP [9.10.05]
by John Allen Paulos

But the theory of evolution does explain the evolution of complex biological organisms and phenomena, and the argument from design, which dates from the 18th century, has been decisively refuted. Rehashing the refutation is not my goal. Those who reject evolution are usually immune to such arguments.

Rather, my intention here is to develop some loose analogies between these biological issues and related economic ones and to show that these analogies point to a surprising crossing of political lines. Let me begin by asking how it is that modern free market economies are as complex as they are, boasting amazingly elaborate production, distribution and communication systems?...

[Editor's Note: First published in *The Guardian* on September 8th]

[...continue]

A Note from the Editor:

The Edgies have been busy writing OpEds and articles in leading newspapers and magazines bringing "intelligent thought" to bear on the issues of the day.

I was tempted to call "Intelligent Thought" on *Edge* a "special edition", but there's nothing special about smart people thinking intelligently in support of science. In this regard, *Edge* is initiating an ongoing feature called "Intelligent Thought on *Edge*", that will give members of the Edge community an opportunity to present their writings on evolutionary science to each other and to our readers.

— JB

[...continue]

Trivers' early work set the foundation for a biologically based system of ethics, in which a preference for some sorts of justice was part of our nature. Matt Ridley, whose book The Origins of Virtue is largely an expansion and restatement of Trivers's argument, says that when he was a student at Oxford, and got a postcard from Trivers asking for a reprint of one of his papers, "It was like getting a postcard from God"; and the whole line of popularising Darwinian books from Richard Dawkins all the way down to Steven Pinker descends from Trivers's insights.

The kindness of strangers
Andrew Brown
Saturday August 27, 2005

Despite switching disciplines — from maths to law to history then the sciences — Robert Trivers profoundly influenced evolutionary biology with his theory that our sense of justice has Darwinian explanations. But he suffered severe mental breakdowns and his career at Harvard was dogged by controversy. After 15 years in genetics he has now turned to anthropology

[...continue]

August 28, 2005

Brilliant!

Michael Wright enjoys a eureka moment at the edge of knowledge, as scientists ponder the imponderable

Here is a good-news story: a website that will expand your mind. Edge.org is a forum for science, philosophy and culture that maps the boundary fence over which today’s big thinkers, standing on tiptoes, are peering. Well-known scientists and assorted eggheads can post their opinions on hotly debated topics of the moment — from the evolutionary biologist Richard Dawkins, discussing why science has more in common with literature than we might think, to the leading geneticist and human-genome maverick J Craig Venter on why he wants to create life.

[...continue]

THE CASE AGAINST INTELLIGENT DESIGN [9.1.05]
The Faith That Dare Not Speak Its Name
by Jerry Coyne

In the end, many Americans may still reject evolution, finding the creationist alternative psychologically more comfortable. But emotion should be distinguished from thought, and a "comfort level" should not affect what is taught in the science classroom. As Judge Overton wrote in his magisterial decision striking down Arkansas Act 590, which mandated equal classroom time for "scientific creationism":

> The application and content of First Amendment principles are not determined by public opinion polls or by a majority vote. Whether the proponents of Act 590 constitute the majority or the minority is quite irrelevant under a constitutional system of government. No group, no matter how large or small, may use the organs of government, of which the public schools are the most conspicuous and influential, to foist its religious beliefs on others.

[Editor's Note: First published in *The New Republic* on August 22nd]

[...continue]

WHO DESIGNED THE DESIGNER? [9.3.05]
by Marcelo Gleiser

If I had the opportunity to meet the assumed designer, I'd ask what, to me, is the most important question of them all: ''Mr. Designer, who designed you?" If the designer answers that it doesn't know, that perhaps it was also designed, we fall into an endless regression, straight back to the problem of the first cause, the one that needs no cause. At this point the mask tumbles and we finally discover the true identity of the IDists' Designer. We should capitalize the word, as this is how we are taught to refer to God.

[Editor's Note: First published in *The Boston Globe*, on August 29th]

[...continue]

ONE SIDE CAN BE WRONG [9.1.05]
by Richard Dawkins & Jerry Coyne

The seductive "let's teach the controversy" language still conveys the false, and highly pernicious, idea that there really are two sides. This would distract students from the genuinely important and interesting controversies that enliven evolutionary discourse. Worse, it would hand creationism the only victory it realistically aspires to. Without needing to make a single good point in any argument, it would have won the right for a form of supernaturalism to be recognised as an authentic part of science. And that would be the end of science education in America.

[Editor's Note: First published in *The Guardian*, on Thursday, September 1st]

[...continue]

UNINTELLIGENT DESIGN [8.30.05]
by Scott Atran

Science, then, may never replace religion in the lives of most people and in any society that hopes to survive for very long. But neither can religion replace science if humankind hopes to unlock nature's material secrets. And parodies of science, like the so-called "theory" of intelligent design, only cripple science education.

[continue]

SHOW ME THE SCIENCE [8.29.05]
by Daniel C. Dennett

Since there is no content, there is no "controversy'' to teach about in biology class. But here is a good topic for a high school course on current events and politics: Is intelligent design a hoax? And if so, how was it perpetrated?

Editor's Note: First published as an Op-Ed Page article in *The New York Times* on Sunday, August 28th.]

[...continue]

All these theories are preposterous, but that's not my problem with them. My problem is that no conceivable experiment can confirm the theories, as most proponents reluctantly acknowledge. The strings (or membranes, or whatever) are too small to be discerned by any buildable instrument, and the parallel universes are too distant. Common sense thus persuades me that these avenues of speculation will turn out to be dead ends.

IN DEFENSE OF COMMON SENSE [8.15.05]
By John Horgan

John Horgan, author of *The End of Science*, and feisty and provocative as ever, is ready for combat with scientists in the *Edge* community. "I'd love to get Edgies' reaction to my OpEd piece — "In Defense of Common Sense" — in *The New York Times*", he writes. Physicist Leonard Susskind, writing "In Defense of Uncommon Sense", is the first to take up Horgan's challenge.

[Editor's Note: First published as an Op-Ed Page article in *The New York Times* on August 12th]

THE REALITY CLUB: Verena Huber-Dyson, Robert Provine, Spencer Reiss, Daniel

Gilbert, John McCarthy, Leonard Susskind respond to John Horgan. Horgan replies.

[continue]

IN DEFENSE OF UNCOMMON SENSE

Leonard Susskind responds to John Horgan

LEONARD SUSSKIND
Felix Bloch Professor of Theoretical Physics, Stanford University

Instead of dyspeptically railing against what he plainly does not understand, Horgan would do better to take a few courses in algebra, calculus, quantum mechanics, and string theory. He might then appreciate, even celebrate, the wonderful and amazing capacity of the human mind to find uncommon ways to comprehend the incomprehensible.

[*A MADMAN DREAMS OF TURING MACHINES*](#) [8.15.05]
by Janna Levin

Gödel didn't believe that truth would elude us. He proved it would. He didn't invent a myth to conform to his prejudice of the world at least not when it came to mathematics. He discovered his theorem as surely as if it was a rock he had dug up from the ground. He could pass it around the table and it would be as real as that rock. If anyone cared to, they could dig it up where he buried it and find it just the same. Look for it and you'll find it where he said it is, just off center from where you're staring. There are faint stars in the night sky that you can see but only if you look to the side of where they shine. They burn too weakly or are too far to be seen directly, even if you stare. But you can see them out of the corner of your eye because the cells on the periphery of your retina are more sensitive to light. Maybe truth is just like that. You can see it, but only out of the corner of your eye.

THE REALITY CLUB: John McCarthy responds to Janna Levin.

[continue]

FEUILLETON
SPIDER FLOWERS: Katinka Matson's Scanner Art Fascinates With Intensive Clarity
Andrian Keye
Monday, August 1, 2005

Ever since Marcel Duchamp mounted the front wheel of a bycicle onto a bar stool, the anarchic use of everyday technologies has been part of the standard repertoire of Modern Art. Usually such works question our perception by distorting reality. The flower images by the New York artist Katinka Matson are different for their exactness and completeness: the surreal aura of her pictures come from their enormous clarity. The flowers seem to radiate from the inside and the details are recognizable into the last fiber as though they were being viewed under a magnifying glass

Original German text ...continue

Spiders (2005)

Canvas (6 ft x 4ft)	Copyright © 2005 Katinka Matson

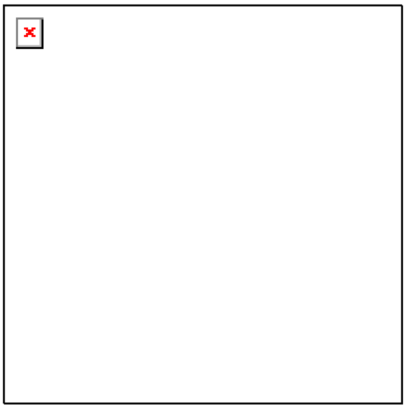
The distinguished Hamburg Bitfilm Festival annually documents how digital technology is revolutionizing film-making and photography. For the first time Hubert Burda Media and the HypoVereinsbank, in co-operation with Bitfilm, present this forum for professionals and creative people from all world on 22 July in Munich at "Bundesgartenschau in München 2005" (BUGA 05), the German National Garden Show.

In a "Best OF" program bitfilm@BUGA the most creative and innovative digital work of the past year is demonstrated. 3D animations, digital effects and Flash Movies are shown plus films, which develop in the virtual worlds of computer games and small EXE files, which produce in the computer in real time 3D-Animation— an amazing cross section of film, photography, art and technology — inspired!

All are invited to enjoy the summer evening in of Munich's most beautiful garden with the Hamburg VJs of Eins23.tv, who presents a Live Remix of the DVD "Brazilectro", underlaid with Digi tie-clips from Rio de Janeiro and São Paulo. Followed of scene DJ Nikias Hofmann (P1, secret society) with open END program; plus the digital images of the New York artist Katinka Matson.

GÖDEL AND THE NATURE OF MATHEMATICAL TRUTH II [7.27.05]

A Talk with Verena Huber-Dyson



I doubt that pure philosophical discourse can get us anywhere. Maybe phenomenological narrative backed by psychological and anthropological investigations can shed some light on the nature of Mathematical Truth.

As to Beauty in mathematics and the sciences, here speaks Sophocles' eyewitness in Antigone:

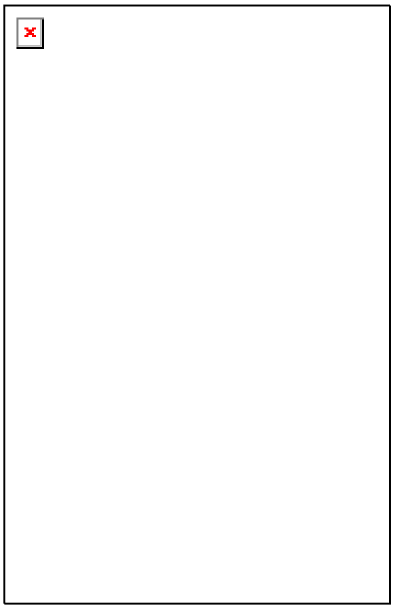
> "..... Why should I make it soft for you with tales to prove myself a liar? Truth is Right."

Princeton,

1950s

Einstein & Gödel
Photo by Oskar Morgenstern, Institute of Advanced Study Archives

A true Realist, a true Platonist will not stoop to choose between Beauty and Truth, he will have the tenacity to stick it through until Truth is caught shining in her own Beauty. Sure there are messy proofs, we have to bushwhack trough a wilderness of ad hoc arguments, tours de force, combinatorial jungles, false starts and the temptations of definitions ever so slightly off target. Eventually, maybe not in our own lifetime, a good proof, a clear and beautiful proof will be honed out.



VHD
Self-Portrait

That, I think, is the belief of the true Platonist. What Gödel and Einstein were doing when walking together over the Institute's grounds may have been just that; bush whacking, comparing mental notes and encouraging each other not to give up while getting all scratched and discouraged. Yet finding solace in speaking to each other in their mother tongue about their deepest concerns, and the state of the cosmos, the world, the weather and their households too.

It's Summer, time to lie on the beach and relax with a wonderful book. Here's a selection of 40 recently published great Summer reads from the *Edge* community. Read Mandelbrot on "multifractals", Dawkins on "true heredity", Penrose on "Clifford bundles", Marcus on "synaptic strengthening", Searle on "biological naturalism", Leroi on "intersex", Pinker on "biological nature", Garreau on "the telekinetic monkey", Seligman on "avoidant people", Randall on "extra dimensions", Kurzweil on "the singularity", Damasio on "neurotransmitter nuclei", Greene on "quantum weirdness", Dennett on the "Zombic Hunch", Diamond on anthropology to zoology, plus many others. You can't go wrong.

Third culture books from: Simon Baron-Cohen, John Barrow, Paul Bloom, John Brockman, David Buss, Antonio Damasio, Richard Dawkins, Daniel C. Dennett, Keith Devlin, Thomas DeZengotita, Jared Diamond, Niles Eldredge, Kenneth Ford, Joel Garreau, Neil Gershenfeld, Rebecca Goldstein, Brian Greene, Haim Harari, Sam Harris, Gerald Holton, John Horgan, George Johnson, Steven Johnson, Ray Kurzweil, Armand Marie Leroi, Benoit Mandlebrot, Gary Marcus, John Markoff, Earnst Mayr, Ian McEwan, James O'Donnell, Roger Penrose, Cliff Pickover, Steven Pinker, Lisa Randall, John Searle, Martin E.P. Seligman, Michael Shermer, Robert Trivers, Edward O. Wilson.

....Continue

AN EPIDEMIOLOGY OF REPRESENTATIONS [7.27.05]
A Talk with Dan Sperber

photo: Leila Pozzo

Dan Sperber *Edge* Video Broadband | Modem

How do the microprocesses of cultural transmission affect the macro structure of culture, its content, its evolution? The microprocesses, the small elementary processes of interest, are both those which happen inside individuals' mind — the cognitive psychological processes, on the one hand, and on the other hand, the interactions among individuals through the changes they bring about in their common environment, and in particular, communication.

Just as the human mind is not a blank slate on which culture would somehow imprint its content, the communication process is not a xerox machine copying process from one mind to another. This is where I part company not just from your standard semiologists or social scientists who take communication to be an unproblematic copying system, a transmission system, biased only by social interest, for instance, almost in intentional distortion but that otherwise would guarantee a kind of smooth flow of undistorted information. I also part company from Richard Dawkins who sees cultural transmission as based on a process of replication, and who assume that communication, imitation, provide a robust replication system.

....Continue

THE EDGE OF COMPUTATION

BIOCOMPUTATION
A Conversation with J. Craig Venter, Ray Kurzweil, Rodney Brooks [6.29.05]

[J. Craig Venter](#) [Ray Kurzweil](#) [Rodney Brooks](#)

Introduction

One aspect of our culture that is no longer open to question is that the most significant developments in the sciences today (i.e. those that affect the lives of everybody on the planet) are about, informed by, or implemented through advances in software and computation. In no other field is this as evident as in the biology and, in this regard, each of the panelists in this *Edge* conversation exemplifies this new trend.

For examples, just as this edition of *Edge* goes to "press", today's *The Wall Street Journal* ran a front page story on Craig Venter's goal of creating life itself. Venter is one of leading scientists of the 21st century for his visionary contributions in genomic research. He is advancing the science of genomics and in applying genomic advances to some of the world's most vexing public health and environmental challenges. Major research foci include human genomic medicine, environmental and evolutionary genomics (which includes the Venter Institute Global Sampling Mission), biological energy production, synthetic biology, and the intersection between genomics and environmental and energy policy.

> ROCKVILLE, Md. -- Biologist J. Craig Venter once raced the U.S. government to complete the decoding of the human genome. Now, after a maverick career studying the code of life, Dr. Venter has a new goal: life itself.
>
> Along with two veteran collaborators, Dr. Venter hopes to become the first to whip up a made-to-order bacterium. Normally, new life is created via reproduction, with each generation passing its genes on to the next. But Dr. Venter aims to bypass that process by manufacturing a complete set of genes, or genome, of a single-cell bacterium in his laboratory. This man-made genome would be installed inside a bacterium whose own genes have been removed.
>
> By creating such a life form, Dr. Venter's researchers think they may come closer to understanding what life is and how scientists can manipulate it for the benefit of humankind. New artificial species could open avenues for industrial production of drugs, chemicals or clean energy.
>
> "This is the step we have all been talking about. We're moving from

reading the genetic code to writing it," Dr. Venter says, swiveling in his chair at his sprawling scientific headquarters here.

(Antonio Regaldo, "Next Dream for Venter: Create Entire Set of Genes From Scratch", *The Wall Street Journal,* June 29, 2005; Page A1)

Rod Brooks' midlife research crisis has been to move away from looking at humanoid robots and toward looking at the very simple question of what makes something alive — what the organizing principles are that go on inside living systems. In his lab at MIT, his is trying to build robots that have properties of living systems that robots haven't had before.

Brooks is puzzled that "we've got all these biological metaphors that we're playing around with — artificial immunology systems, building robots that appear lifelike — but none of them come close to real biological systems in robustness and in performance. They look a little like it, but they're not really like biological systems." He worries that in looking at biological systems we are missing something that is already there — that has always been there. To Brooks, this might be called "the essence of life," but he is talking about a biochemical phenomenon, not a metaphysical one. Brooks is searching for a new conceptual framework that, like computation, does not involve any new physics or chemistry — a framework that gives us a different way of thinking about the stuff that's there. "We see the biological systems, we see how they operate," he says, "but we don't have the right explanatory modes to explain what's going on and therefore we can't reproduce all these sorts of biological processes. That to me right now is the deep question."

Ray Kurzweil believes "we are entering a new era. Some of us call it the Singularity. It's a merger between human intelligence and machine intelligence which is going to create something bigger than itself. It's the cutting edge of evolution on our planet. One can make a strong case that it's actually the cutting edge of the evolution of intelligence in general, because there's no indication that it has occurred anywhere else. To me that is what human civilization is all about. It is part of our destiny, and part of the destiny of evolution, to continue to progress ever faster and to grow the power of intelligence exponentially."

In this *Edge* Reality Club conversation, three of the world's leading scientists ask each other the questions they are asking themselves about biocomputation.

Take research and experimentation down an empirical road road and you come to a an wall where everything changes, and you blow all your epistemological biases and need new language, new ideas, new paradigms. This is the intersection of the empirical and the epistemological...where *Edge* likes to hang out.

In 1998, J. CRAIG VENTER became the first president of Celera Genomics to sequence the human genome using the whole genome shotgun technique, new mathematical algorithms, and new automated DNA sequencing machines. The completed sequence of the human genome was published in February 2001 in the journal, Science. In addition to the human genome, Venter and his team at Celera sequenced the fruit fly, mouse, and rat genomes. In 2003, Venter launched a global expedition to obtain and study microbes from environments ranging from the world's oceans to urban centers. This mission, now in progress, is yielding insights into genes that make up the vast realm of microbial life. He is founder and president of the J. Craig Venter Institute and the J. Craig Venter Science Foundation.

Craig Venter *Edge* Video Broadband | Modem

RAY KURZWEIL, an inventor and entrepreneur, has been pushing the technological envelope for years in his field of pattern recognition. He was the principal developer of the first omni-font optical character recognition system, the first print-to-speech reading machine for the blind, the first CCD flat-bed scanner, the first text-to speech synthesizer, the first music synthesizer capable of recreating the grand piano and other orchestral instruments, and the first commercially marketed large vocabulary speech recognition system. He is the author of *The Age of Intelligent Machines; The Age of Spiritual Machines, When Computers Exceed Human Intelligence;* (with Terry Grossman, M.D.) *Fantastic voyage: Live Long Enough to Live Forever;* and the upcoming book, *The Singularity is Near, When Humans Transcend Biology.*

Ray Kurzweil *Edge* Video Broadband | Modem

RODNEY BROOKS, a computer scientist and AI researcher, is interested in making living systems.

Brooks is Director of the MIT Computer Science and Artificial Intelligence Laboratory (CSAIL), and Fujitsu Professor of Computer Science. He is also co-founder and Chief Technical Officer of iRobot Corporation, which has brought you the Roomba vacuum cleaner, the Scooba robotic floor washer and the robots that disarm the Improvised Explosive Devices (IEDs) in Iraq. His most recent book was *Flesh and Machines: How Robots Will Change Us.*

Rodney Brooks *Edge* Video Broadband | Modem

Conference (Technology, Entertainment, Design) in Monterey California. [ED NOTE: TED Global takes place in Oxford, England July 12-15. Craig Venter is among many *Edge* regulars who are speaking).

I am pleased to present J. Craig Venter, Ray Kurzweil, and Rodney Brooks on "Biocomputation".

— JB

...Continue

GÖDEL AND THE NATURE OF MATHEMATICAL TRUTH [6.8.05]

A Talk with Rebecca Goldstein

Rebecca Goldstein *Edge* Video Broadband | Modem

Gödel mistrusted our ability to communicate. Natural language, he thought, was imprecise, and we usually don't understand each other. Gödel wanted to prove a mathematical theorem that would have all the precision of mathematics—the only language with any claims to precision—but with the sweep of philosophy. He wanted a mathematical theorem that would speak to the issues of meta-mathematics. And two extraordinary things happened. One is that he actually did produce such a theorem. The other is that it was interpreted by the jazzier parts of the intellectual culture as saying, philosophically exactly the opposite of what he had been intending to say with it.

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re: THE SCIENCE OF GENDER AND SCIENCE — PINKER VS. SPELKE — A DEBATE

Diane F. Halpern, Alison Gopnik, David Haig, Nora S. Newcombe on "Pinker vs.

Spelke"

NEW Steven Pinker responds to Halpern, Gopnik, Haig, and Newcomb [Continue...]

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re: THE ASSORTATIVE MATING THEORY
A Talk with Simon Baron-Cohen

Simon Baron-Cohen responds to Marc D. Hauser, Steven Pinker, Armand Leroi, Carole Hooven, Elizabeth Spelke, Alison Gopnik, David C. Geary, Helena Cronin, Linda S. Gottfredson on sex differences, linguistic ambiguity, systemizers, empathizers, politics in science, and the assortative mating theory. [Continue...]

AN EDGE SPECIAL EVENT

THE SCIENCE OF GENDER AND SCIENCE

PINKER VS. SPELKE

A DEBATE

[5.10.05]

...on the research on mind, brain, and behavior that may be relevant to gender disparities in the sciences, including the studies of bias, discrimination and innate and acquired difference between the sexes.

Harvard University • Mind/Brain/Behavior Initiative

The Mind Brain and Behavior Inter-Faculty Initiative (MBB), under the leadership of Co-Directors Marc D. Hauser and Elizabeth Spelke, is a university-wide community that studies the structure, function, evolution, development, and pathology of the nervous system, in relation to decision-making and behavior.

[...more]

Review
April 30, 2005
by Andrew Brown

THE HUSTLER

[Brockman is] an impresario and promoter of scientific ideas who is changing the way that all educated people think about the world. Richard Dawkins, his friend and client, says, "his Edge web site has been well described as an online salon, for scientists and for other intellectuals who care about science. John Brockman may have the most enviable address book in the English-speaking world, and he uses it to promote science and scientific literature in a way that nobody else does." ...

...Brockman has constantly reinvented himself. He has been at the leading edge of intellectual fashion for the past 30 years. In the late 90s, just before the dot.com bubble popped, he told an interviewer from *Wired* magazine that he wanted to be "post-interesting". Looking back on all the ideas he has enthused about you glimpse a mind that rushes around like a border collie — tirelessly and gracefully pursuing anything that moves, but absolutely uninterested in things that stay still, and liable, if shut up in a car, to get bored and eat all the upholstery. Like a lot of successful salesmen, part of his secret is that he is interested in people for their own sake as well as for what they can do for him, and can study them with extraordinary concentration, solemnly placing out, beside the journalist's machine, two tape recorders of his own at the beginning of an interview. To be under his attentive, almost affectionate gaze, is to know how a sheep feels in front of a collie.

[...more]

THE MATHEMATICS OF LOVE *[4.14.05]*
A Talk with John Gottman

John Gottman *Edge* Video Broadband | Modem

We were able to derive a set of nonlinear difference equations for marital interaction as well as physiology and perception. These equations provided parameters, that allowed us to predict, with over 90 percent accuracy, what was going to happen to a relationship over a three-year period. The main advantage of the math modeling was that using these parameters, we are not only be able to predict, but now *understand* what people are doing when they affected one another. And through the equations we were now really able to build theory. That theory allows us to understand how to intervene and how to change things. And how to know what it is we're affecting, and why the interventions are effective. This is the mathematics of love.

THE ASSORTATIVE MATING THEORY *[4.6.05]*
A Talk with Simon Baron-Cohen

My thesis with regard to sex differences is quite moderate, in that I do not discount environmental factors; I'm just saying, don't forget about biology. To me that sounds very moderate. But for some people in the field of gender studies, even that is too extreme. They want it to be all environment and no biology. You can understand that politically that was an important position in the 1960s, in an effort to try to change society. But is it a true description, scientifically, of what goes on? It's time to distinguish politics and science, and just look at the evidence.

THE REALITY CLUB: Marc D. Hauser, Steven Pinker, Armand Leroi, Carole Hooven, Elizabeth Spelke, Alison Gopnik, David C. Geary, Helena Cronin, Linda S. Gottfredson.
NEW Simon Baron-Cohen responds on sex differences, linguistic ambiguity, systemizers, empathizers, sexual politics in science, and the assortative mating theory.

April 4, 2005
by Edoardo Boncinelli

"THE NEW HUMANISTS AND THE FUTURE. BETWEEN SCIENCE AND SCIENCE FICTION."

The main thesis of this book is very interesting and challenging: modern science is blowing fresh air into the contemporary cultural agenda, making a very important contribution, sparkling and polychromatic. (...) A book like this one may be read in many different ways, following different propensities and needs. I was enlightened by the windows it opens on our future.

[From a review in *Corriere della Sera* of *I Nuovi Umanisti* (the Italian translation of *The New Humanists*, Garzanti Libri) — the best of *Edge*— now available in a book. See below.]

April 2005

I call it "Broks's paradox": the condition of believing that the mind is separate from the body, even though you know this belief to be untrue

Paul Broks

I've been browsing the "World Question Centre" at edge.org, the website for thinking folk with time on their hands. The 2005 *Edge* question is a good one: "What do you believe is true even though you cannot prove it?"

...

Ian McEwan" makes a telling point. "What I believe but cannot prove," he says, "is that no part of my consciousness will survive my death." His enlightened fellow *Edge* contributors will take this as a given, but they may not appreciate its significance, which is that belief in an afterlife "divides the world crucially, and much damage has been done to thought as well as to persons by those who are certain that there is a life, a better, more important life, elsewhere." The natural gift of consciousness should be treasured all the more for its transience.

.....click here for article

March 12, 2005
Inserto Tuttolibri: Libri, Recensioni E Presentazioni

URGE UNA "TERZA CULTURA"
Ermanno Bencivenga

In Brockman's intentions, this running fire of a provocative and fascinating thesis should provoke a healthy optimism. The "new humanists" of his book are *those scientists and other thinkers in the empirical world who, through their work and expository writing, are taking the place of the traditional intellectual in rendering visible the deeper meanings of our lives, redefining who and what we are*. Their turn then to speak: biologists, computer scientists, geographers, physicists, astronomers, inventors outline in a few pages their own experience and ideas.

The "third culture" invoked by John Brockman is now an absolute necessity. We can't stand unproductive fences and mutual misunderstandings anymore.

[From a review in *La Stampa* of *I Nuovi Umanisti* (the Italian translation of *The New Humanists*, Garzanti Libri) — the best of *Edge*, now available in a book. See below.]

THE NATURE OF NORMAL HUMAN VARIETY *[3.15.03]*
A Talk with Armand Leroi

Armand Leroi *Edge* Video Broadband | Modem

Of course, there will be people who object. There will be people who will say that this is a revival of racial science. Perhaps so. I would argue, however, that even if this is a revival of *racial* science, we should engage in it for it does not follow that it is a revival of *racist* science. Indeed, I would argue, that it is just the opposite.

THE REALITY CLUB: James J. ODonnell, Andrew Brown, Tim D. White, Alun Andeson, Nicholas Humphrey respond to Armand Leroi

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AN EDGE SPECIAL EVENT

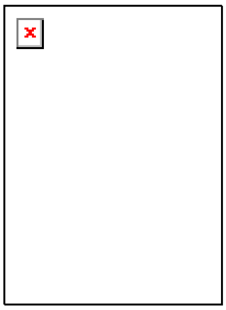
THE PANCAKE PEOPLE, OR, "THE GODS ARE POUNDING MY HEAD [3.6.05]
Richard Foreman

But today, I see within us all (myself included) the replacement of complex inner density with a new kind of self-evolving under the pressure of information overload and the technology of the "instantly available". A new self that needs to contain less and less of an inner repertory of dense cultural inheritance—as we all become "pancake people"—spread wide and thin as we connect with that vast network of information accessed by the mere touch of a button.

RICHARD FOREMAN, Founder Director, Ontological-Hysteric Theater, has written, directedand designed over fifty of his own plays both in New York City and abroad. Five of his plays have received "OBIE" awards as best play of the year—and he has received five other "OBIE'S" for directing and for 'sustained achievement'.

vs.

THE GÖDEL-TO-GOOGLE NET
George Dyson



As Richard Foreman so beautifully describes it, we've been pounded into instantly-available pancakes, becoming the unpredictable but statistically critical synapses in the whole Gödel-to-Google net. Does the resulting mind (as Richardson would have it) belong to us? Or does it belong to something else?

GEORGE DYSON, science historian, is the author of *Darwin Among the Machines.*

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Introduction

In early 2001, avant-garde playwright and director Richard Foreman, called to enquire about *Edge*'s activities. He had noticed the optimism of the *Edge* crowd and the range of intellectual interests and endeavors and felt that he needed to to begin a process to explore these areas. Then 9/11 happened. We never had our planned meeting.

Several years have gone by and recently Foreman opened his most recent play for his Ontological-Hysteric Theater at St. Marks Church in the Bowery in New York City. He also announced that the play—*The Gods Are Pounding My Head*—would be his last.

Foreman presents *Edge* with a statement and a question. The statement appears in his program and frames the sadness of *The Gods Are Pounding My Head*. The question is an opening to the future. With both, Foreman belatedly hopes to engage *Edge* contributors in a discussion, and in this regard George Dyson has written the initial response, posted along with others, entitled "The Gödel-to-

Google Net".

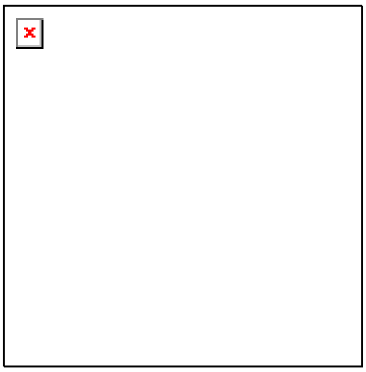
THE REALITY CLUB: Kevin Kelly, Jaron Lanier, Steven Johnson, Marvin Minsky, Douglas Rushkoff, Roger Schank, James O'Donnell, Rebecca Goldstein, respond to Richard Foreman and George Dyson

Continue...

EDGE AT TED 2005

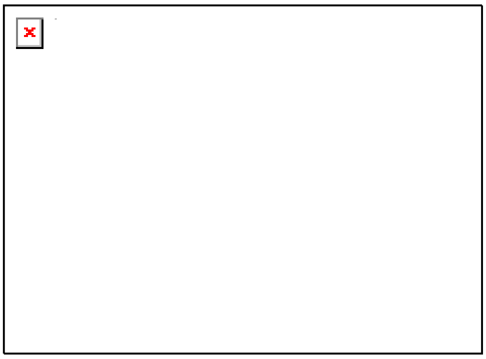
Craig Venter; Sergey Brin & Larry Page, Google; JB

On February 22nd, *Edge* presented a Reality Club Meeting at TED 2005, the annual conference in Monterey, CA for the movers and shakers in Technology, Entertainment, Design. The topic was "Science at the Edge: Rebooting Biology" and dealt with the intersection of biology and computation. The panelists were Rodney Brooks, Ray Kurzweil and Craig Venter.

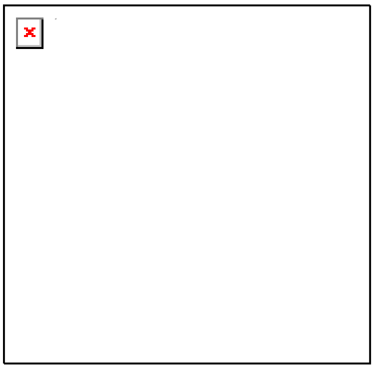


MacKenzie & Jeff Bezos

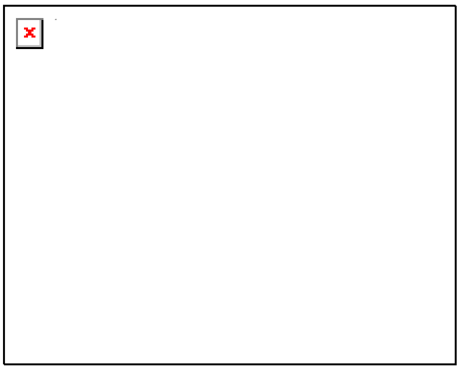
In recent years, science has also become a central part of TED. In fact, nowhere else will you find such an intense concentration of major third culture intellectuals. And it's not just about their talks. Most of the speakers stick around for 3-4 days and are accessible to the other attendees. This year the list of scientists included: Rod Brooks, Robert Full, Brian Greene, Danny Hillis, Olivia Judson, Irene Pepperberg, Paul Sereno, Craig Venter, James Watson. Add to that mix science-minded thinkers such as Stewart Brand, Kevin Kelly, Howard Rheingold, Jeff Bezos, plus computer science pioneers such as Sergey Brin and Larry Page, inventors Ray Kurzweil and Dean Kamen, and finally top editors from F*ortune, Time, Discover, Wired, Wall Street Journal*.....it's was quite a week.



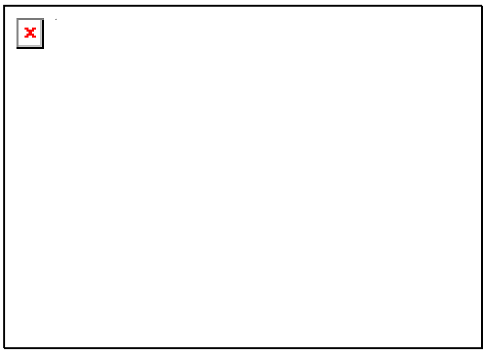
Rodney Brooks, Brian Greene



Peter Petre, *Fortune*



Stewart Brand; Lori Park, Google



Philip Elmer-DeWitt, *Time*
Steve Petranek, *Discover*

[The text of the *Edge* Reality Club Meeting featuring Rod Brooks, Ray Kiurzweil, and Craig Venter will appear in due course. The event was well-attended; the TEDsters were clearly into it.]

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Gaps in the Mind

By Richard Dawkins
Excerpted from The Great Ape Project, edited by Paola Cavalieri and Peter Singer
London: Fourth Estate, 1993.

Sir,
You appeal for money to save the gorillas. Very laudable, no doubt. But it doesn't seem to have occurred to you that there are thousands of human children suffering on the very same continent of Africa. There'll be time enough to worry about gorillas when we've taken care of every last one of the kiddies. Let's get our priorities right, please!
This hypothetical letter could have been written by almost any well-meaning person today. In lampooning it, I don't mean to imply that a good case could not be made for giving human children priority. I expect it could, and also that a good case could be made the other way. I'm only trying to point the finger at the automatic, unthinking nature of the speciesist double standard. To many people it is simply self-evident, without any discussion, that humans are entitled to special treatment. To see this, consider the following variant on the same letter:

Sir,
You appeal for money to save the gorillas. Very laudable, no doubt. But it doesn't seem to have occurred to you that there are thousands of aardvarks suffering on the very same continent of Africa. There'll be time enough to worry about gorillas when we've saved every last one of the aardvarks. Let's get our priorities right, please!
This second letter could not fail to provoke the question: What's so special about aardvarks? A good question, and one to which we should require a satisfactory answer before we took the letter seriously. Yet the first letter, I suggest, would not for most people provoke the equivalent question--What's so special about humans? As I said, I don't deny that this question, unlike the aardvark question, very probably has a powerful answer. All that I am criticising is an unthinking failure to realise in the case of humans that the question even arises.

The speciesist assumption that lurks here is very simple. Humans are humans and gorillas are animals. There is an unquestioned yawning gulf between them such that the life of a single human child is worth more than the lives of all the gorillas in the world. The 'worth' of an animal's life is just its replacement cost to its owner--or, in the case of a rare species, to humanity. But tie the label Homo sapiens even to a tiny piece of insensible, embryonic tissue, and its life suddenly leaps to infinite, uncomputable value.

This way of thinking characterises what I want to call the discontinuous mind. We would all agree that a six-foot woman is tall, and a five-foot woman is not. Words like 'tall' and 'short' tempt us to force the world into qualitative classes, but this doesn't mean that the world really is discontinuously distributed. Were you to tell me that a woman is five feet nine inches tall, and ask me to decide whether she should therefore be called tall or not, I'd shrug and say 'She's five foot nine, doesn't that tell you what you need to know?' But the discontinuous mind, to caricature it a little, would go to court (probably at great expense) to decide whether the woman was tall or short. Indeed, I hardly need to say caricature. For years, South African courts have done a brisk trade adjudicating whether particular individuals of mixed parentage count as white, black or coloured.

The discontinuous mind is ubiquitous. It is especially influential when it afflicts lawyers and the religious (not only are all judges lawyers; a high proportion of politicians are too, and all politicians have to woo the religious vote). Recently, after giving a public lecture, I was cross-examined by a lawyer in the audience. He brought the full weight of his legal acumen to bear on a nice point of evolution. If species A evolves into a later species B, he reasoned closely, there must come a point when a mother belongs to the old species A and her child belongs to the new species B. Members of different species cannot interbreed with one another. I put it to you, he went on, that a child could hardly be so different from its parents that it could not interbreed with their kind. So, he wound up triumphantly, isn't this a fatal flaw in the theory of evolution?

But it is we that choose to divide animals up into discontinuous species. On the evolutionary view of life there must have been intermediates, even though, conveniently for our naming rituals, they are usually extinct: usually, but not always. The lawyer would be surprised and, I hope, intrigued by so-called 'ring species'. The best-known case is herring gull versus lesser black-backed gull. In Britain these are clearly distinct species, quite different in colour. Anybody can tell them apart. But if you follow the population of herring gulls westward round the North Pole to North America, then via Alaska across Siberia and back to Europe again, you will notice a curious fact. The 'herring gulls' gradually become less and less like herring gulls and more and more like lesser black-backed gulls until it turns out that our European lesser black-backed gulls actually are the other end of a ring that started out as herring gulls. At every stage around the ring, the birds are sufficiently similar to their neighbours to interbreed with them. Until, that is, the ends of the continuum are reached, in Europe. At this point the herring gull and the lesser black-backed gull never interbreed, although they are linked by a continuous series of interbreeding colleagues all the way round the world. The only thing that is special about ring species like these gulls is that the intermediates are still alive. All pairs of related species are potentially ring species. The intermediates must have lived once. It is just that in most cases they are now dead. The lawyer, with his trained discontinuous mind, insists on placing individuals firmly in this species or that. He does not allow for the possibility that an individual might lie half-way between two species, or a tenth of the way from species A to species B. Self-styled 'pro-lifers', and others that indulge in footling debates about exactly when in its development a foetus 'becomes human', exhibit the same discontinuous mentality. It is no use telling these people that, depending upon the human characteristics that interest you, a foetus can be 'half human' or 'a hundredth human'. 'Human', to the discontinuous mind, is an absolute concept. There can be no half measures. And from this flows much evil.

The word 'apes' usually means chimpanzees, gorillas, orangutans, gibbons and slamangs. We admit that we are like apes, but we seldom realise that we are apes. Our common ancestor with the chimpanzees and gorillas is much more recent than their common ancestor with the Asian apes--the gibbons and orangutans. There is no natural category that includes chimpanzees, gorillas and orangutans but excludes humans. The artificiality of the category 'apes', as conventionally taken to exclude humans, is demonstrated by Figure 1. This family tree shows humans to be in the thick of the ape cluster; the artificiality of the conventional category 'ape' is shown by the stippling. In truth, not only are we apes, we are African apes. The category 'African apes', if you don't arbitrarily exclude humans, is a natural one. The stippled area in Figure 2 doesn't have any artificial 'bites' taken out of it.

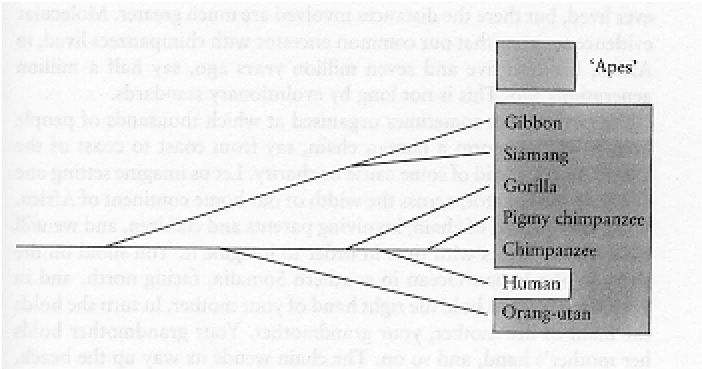

Figure 1

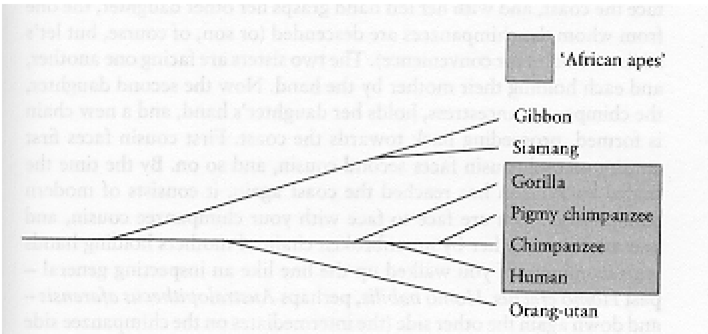

Figure 2

'Great apes', too, is a natural category only so long as it includes humans. We are great apes. All the great apes that have ever lived, including ourselves, are linked to one another by an unbroken chain of parent-child bonds. The same is true of all animals and plants that have ever lived, but there the distances involved are much greater. Molecular evidence suggests that our common ancestor with chimpanzees lived, in Africa, between five and seven million years ago, say half a million generations ago. This is not long by evolutionary standards.

Happenings are sometimes organised at which thousands of people hold hands and form a human chain, say from coast to coast of the United States, in aid of some cause or charity. Let us imagine setting one up along the equator, across the width of our home continent of Africa. It is a special kind of chain, involving parents and children, and we will have to play tricks with time in order to imagine it. You stand on the shore of the Indian Ocean in southern Somalia, facing north, and in your left hand you hold the right hand of your mother. In turn she holds the hand of her mother, your grandmother. Your grandmother holds her mother's hand, and so on. The chain wends its way up the beach, into the arid scrubland and westwards on towards the Kenya border.

How far do we have to go until we reach our common ancestor with the chimpanzees? It is a surprisingly short way. Allowing one yard per person, we arrive at the ancestor we share with chimpanzees in under 300 miles. We have hardly started to cross the continent; we are still not half way to the Great Rift Valley. The ancestor is standing well to the east of Mount Kenya, and holding in her hand an entire chain of her lineal descendants, culminating in you standing on the Somali beach.

The daughter that she is holding in her right hand is the one from whom we are descended. Now the arch-ancestress turns eastward to face the coast, and with her left hand grasps her other daughter, the one from whom the chimpanzees are descended (or son, of course, but let's stick to females for convenience). The two sisters are facing one another, and each holding their mother by the hand. Now the second daughter, the chimpanzee ancestress, holds her daughter's hand, and a new chain is formed, proceeding back towards the coast. First cousin faces first cousin, second cousin faces second cousin, and so on. By the time the folded-back chain has reached the coast again, it consists of modern chimpanzees. You are face to face with your chimpanzee cousin, and you are joined to her by an unbroken chain of mothers holding hands with daughters. If you walked up the line like an inspecting general--past Homo erectus, Homo habilis, perhaps Australopithecus afarensis--and down again the other side (the intermediates on the chimpanzee side are unnamed because, as it happens, no fossils have been found), you would nowhere find any sharp discontinuity. Daughters would resemble mothers just as much (or as little) as they always do. Mothers would love daughters, and feel affinity with them, just as they always do. And this hand-in-hand continuum, joining us seamlessly to chimpanzees, is so short that it barely makes it past the hinterland of Africa, the mother continent.

Our chain of African apes, doubling back on itself, is in miniature like the ring of gulls round the pole, except that the intermediates happen to be dead. The point I want to make is that, as far as morality is concerned, it should be incidental that the intermediates are dead. What if they were not? What if a clutch of intermediate types had survived, enough to link us to modern chimpanzees by a chain, not just of hand-holders, but of interbreeders? Remember the song, 'I've danced with a man, who's danced with a girl, who's danced with the Prince of Wales'? We can't (quite) interbreed with modern chimpanzees, but we'd need only a handful of intermediate types to be able to sing: 'I've bred with a man, who's bred with a girl, who's bred with a chimpanzee.'

It is sheer luck that this handful of intermediates no longer exists. ('Luck' from some points of view: for myself, I should love to meet them.) But for this chance, our laws and our morals would be very different. We need only discover a single survivor, say a relict Australopithecus in the Budongo Forest, and our precious system of norms and ethics would come crashing about our ears. The boundaries with which we segregate our world would be all shot to pieces. Racism would blur with speciesism in obdurate and vicious confusion. Apartheid, for those that believe in it, would assume a new and perhaps a more urgent import.

But why, a moral philosopher might ask, should this matter to us? Isn't it only the discontinuous mind that wants to erect barriers anyway? So what if, in the continuum of all apes that have lived in Africa, the survivors happen to leave a convenient gap between Homo and Pan? Surely we should, in any case, not base our treatment of animals on whether or not we can interbreed with them. If we want to justify double standards--if society agrees that people should be treated better than, say, cows (cows may be cooked and eaten, people may not)--there must be better reasons than cousinship. Humans may be taxonomically distant from cows, but isn't it more important that we are brainier? Or better, following Jeremy Bentham, that humans can suffer more--that cows, even if they hate pain as much as humans do (and why on earth should we suppose otherwise?), do not know what is coming to them? Suppose that the octopus lineage had happened to evolve brains and feelings to rival ours; they easily might have done. The mere possibility shows the incidental nature of cousinship. So, the moral philosopher asks, why emphasise the human/chimp continuity?

Yes, in an ideal world we probably should come up with a better reason than cousinship for, say, preferring carnivory to cannibalism. But the melancholy fact is that, at present, society's moral attitudes rest almost entirely on the discontinuous, speciesist imperative.

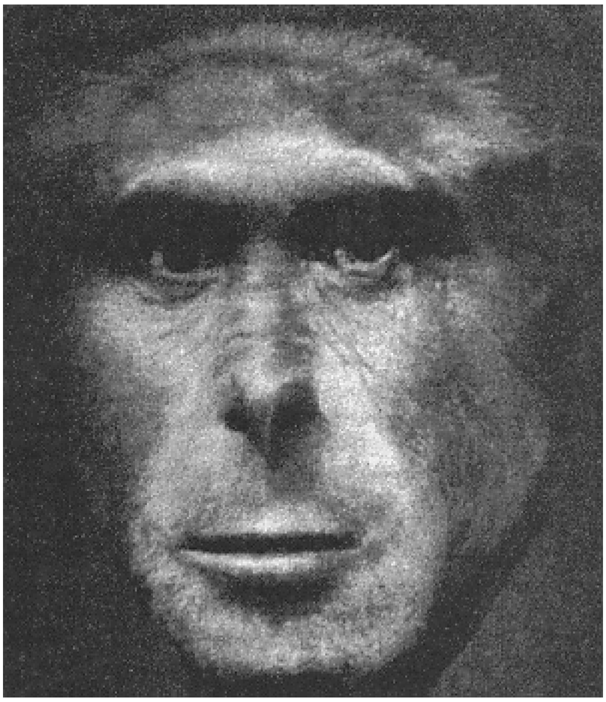

Figure 3 Hypothetical computer-generated image of what an intermediate between a human and a chimpanzee face might look like. [After Nancy Burston and David Kramlich, from C. A. Pickover, Computers and the Imagination: Visual Adventures Beyond the Edge (Alan Sutton, Stroud, 1991).]

This arresting picture is hypothetical. But I can assert, without fear of contradiction, that if somebody succeeded in breeding a chimpanzee/human hybrid the news would be earth-shattering. Bishops would bleat, lawyers would gloat in anticipation, conservative politicians would thunder, socialists wouldn't know where to put their barricades. The scientist that achieved the feat would be drummed out of politically correct common-rooms; denounced in pulpit and gutter press; condemned, perhaps, by an Ayatollah's fatwah. Politics would never be the same again, nor would

theology, sociology, psychology or most branches of philosophy. The world that would be so shaken, by such an incidental event as a hybridisation, is a speciesist world indeed, dominated by the discontinuous mind.

I have argued that the discontinuous gap between humans and 'apes' that we erect in our minds is regrettable. I have also argued that, in any case, the present position of the hallowed gap is arbitrary, the result of evolutionary accident. If the contingencies of survival and extinction had been different, the gap would be in a different place. Ethical principles that are based upon accidental caprice should not be respected as if cast in stone.

Nevertheless, it must be conceded that this book's proposal to admit great apes to the charmed circle of human privilege stands square in the discontinuous tradition. Albeit the gap has moved, the fundamental question is still 'Which side of the gap?' Regrettable as this is, as long as our social mores are governed by discontinuously minded lawyers and theologians, it is premature to advocate a quantitative, continuously distributed morality. Accordingly, I support the proposal for which this book stands.

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Article in The Observer Sunday September 24th, 2000
Greenpeace's action was vandalism and inhibited the need for scientific research

Defence counsel for the Greenpeace vandals reassured the court that his clients were 'the sort of people you may expect to find sitting on a jury'. He was right, of course, with a vengeance. But far from being a character reference for the defendants, it is an indictment of the jury system. I am not in the least surprised to read that after the trial members of the jury were seen 'congratulating defendants'.

What sort of signal has been sent out by this verdict? Is it, as some have said, a charter for burglars, arsonists and telephone box vandals? Can we now freely commit crimes on the assumption that a jury of Big Brother -watching Sun -readers will reach a verdict uncontaminated by the facts of the case? It hasn't quite come to that. But it is close. This, emphatically, is not to be compared with the sort of civil disobedience that can be justified on genuinely thoughtful grounds.

Lord Melchett is no Gandhi, no Mandela, taking direct action as the only possible recourse against an oppressive regime. On the other hand, he and his friends are probably not as sinister as their 'decontamination suit' uniforms suggest. On balance, Lord Melchett is more airheaded wally than Mosleyite stormtrooper.

The air force general in Dr Strangelove who took devastating direct action in defence of 'our precious bodily fluids', is fiction... just. Popular misconceptions about GM foods are well up in the 'precious bodily fluids' class. If you pick 12 people at random, the majority might well think that GM is a substance, like DDT. Or that if they are 'contaminated' by GM they will undergo some Frankensteinian transmogrification. Or they wouldn't understand what is funny about the protesters' slogan: 'We don't want DNA in our tomatoes.' Aren't there some beliefs too daft for 'sincerity' to be an excuse?

Many of us believe the News of the World is an affront to decent humanity. Are we now free to torch its editorial offices? Many people sincerely think abortion is legalised murder. Will the Greenpeace verdict signal open season on doctors and clinics, as happens in some parts of America?

Some people sincerely believe that their private opinions on petrol prices entitle them to take unilateral action and blockade the country's vital supplies. Presumably, Greenpeace would oppose them, since high petrol taxes help to reduce pollution. We don't have to project our imaginations far into the future to envision Greenpeace warriors storming the barricades of fuel-protesting lorry drivers. If there are casualties and damage, should the jury acquit both sides, on the grounds that both sincerely believed their (opposite and incompatible) doctrines?

Is this really the sort of country we want to live in? Is this how we want to decide policy? That is where the Greenpeace verdict seems to be leading us.

The Government may be ruefully wondering whether it has been hoist by its own petard. Was it wise to encourage those outbursts of mindless 'feeling' and all that hysterical caterwauling over the 'People's Princess'? Has feeling become the new thinking? If so, the Government may bear some indirect responsibility.

The late Carl Sagan was once asked a question to which he didn't know the answer and he firmly said so. The questioner persisted: 'But what is your gut feeling?' Sagan's reply is never to be forgotten: 'But I try not to think with my gut. If I'm serious about understanding the world, thinking with anything besides my brain, as tempting as that might be, is likely to get me into trouble. It's OK to reserve judgment until the evidence is in.'

I genuinely don't know what to think about genetically modified crops, and nor should anyone else. The evidence is not yet in. Particular kinds of genetic modification may be a very bad idea. Or they may be a very good idea. It is precisely because we don't know that we have to find out. That is the purpose of experimental trials such as the one sabotaged by Greenpeace. Scientists do not know all the answers and should not claim to. Science is not a testament of doctrines; rather, it is a method of finding out. It is the only method that works by definition, since if a better method comes along, science will incorporate it. If we are not allowed to do experimental trials on genetically modified crops, we shall never know the bad things or the good things about them.

We now know that strong doses of X-rays are very dangerous. They can induce mutations and cause cancers. But if used carefully and in moderation, X-rays are a priceless diagnostic tool. We can all be thankful that predecessor of Greenpeace did not sabotage Roentgen's experiments on X-rays or Muller's investigations of mutagenesis.

We depend on scientific research to predict both the good and bad consequences of innovation. It is a reasonable guess (not a gut feeling) that genetically modified crops will also turn out to have both bad and good aspects. Certainly, it will be possible to modify plants to our benefit. And certainly it would be possible to modify plants in deliberately malevolent directions.

Very likely, as in the case of X-rays, even the good modifications may turn out to have some bad side-effects. It would be better to discover these now, in carefully controlled trials, rather than let them emerge later. With hindsight, it is a pity more research was not done earlier on the dangers of X-rays. If it had been, children of my generation would not have been allowed to play with X-ray machines in shoe shops.

We need more research, not less. And if we are to have activists protesting about dangerous crops, let us draw their zealous attention to those crops whose evil effects are already known because the necessary research was allowed to be done. Like tobacco.

Hall of Mirrors
or What is True?
by Richard Dawkins

Published in Forbes ASAP October 2, 2000

A little learning is a dangerous thing. This has never struck me as a particularly profound or wise remark, but it comes into its own in the special case where the little learning is in philosophy (as it often is). A scientist who has the temerity to utter the t-word ('true') is likely to encounter a form of philosophical heckling which goes something like this.

There is no absolute truth. You are committing an act of personal faith when you claim that the scientific method, including mathematics and logic, is the privileged road to truth. Other cultures might believe that truth is to be found in a rabbit's entrails, or the ravings of a prophet up a pole. It is only your personal faith in science that leads you to favor your brand of truth.

That strand of half-baked philosophy goes by the name of cultural relativism. It is one aspect of the Fashionable Nonsense detected by Alan Sokal and Jean Bricmont, or the Higher Superstition of Paul Gross and Norman Levitt. The feminist version is ably exposed by Noretta Koertge, author of Professing Feminism: Cautionary Tales from the Strange World of Women's Studies:

Women's Studies students are now being taught that logic is a tool of domination. . . the standard norms and methods of scientific inquiry are sexist because they are incompatible with 'women's ways of knowing' . . . These 'subjectivist' women see the methods of logic, analysis and abstraction as 'alien territory belonging to men' and 'value intuition as a safer and more fruitful approach to truth'.

How should scientists respond to the allegation that our 'faith' in logic and scientific truth is just that – faith – not 'privileged' (favorite in-word) over alternative truths? A minimal response is that science gets results. As I put it in River Out of Eden,

Show me a cultural relativist at 30,000 feet and I'll show you a hypocrite. . . If you are flying to an international congress of anthropologists or literary critics, the reason you will probably get there – the reason you don't plummet into a ploughed field – is that a lot of Western scientifically trained engineers have got their sums right.

Science boosts its claim to truth by its spectacular ability to make matter and energy jump through hoops on command, and to predict what will happen and when.

But is it still just our Western scientific bias to be impressed by accurate prediction; impressed by the power to slingshot rockets around Jupiter to reach Saturn, or intercept and repair the Hubble telescope; impressed by logic itself? Well, let's concede the point and think sociologically, even democratically. Suppose we agree, temporarily, to treat scientific truth as just one truth among many, and lay it alongside all the rival contenders: Trobriand truth, Kikuyu truth, Maori truth, Inuit truth, Navajo truth, Yanomamo truth, !Kung San truth, feminist truth, Islamic truth, Hindu truth: the list is endless – and thereby hangs a revealing observation.

In theory, people could switch allegiance from any one ‘truth’ to any other if they decide it has greater merit. On what basis might they do so? Why would one change from, say, Kikuyu truth to Navajo truth? Such merit-driven switches are rare. With one crucially important exception: switches to scientific truth, from any other member of the list. Scientific truth is the only member of the endless list which evidentially convinces converts of its superiority. People are loyal to other belief systems for one reason only: they were brought up that way, and they have never known anything better. When people are lucky enough to be offered the opportunity to vote with their feet, doctors and their kind prosper, while witch doctors decline. Even those who do not, or cannot, avail themselves of a scientific education, choose to benefit from the technology that is made possible by the scientific education of others. Admittedly, religious missionaries have successfully claimed converts in great numbers all over the underdeveloped world. But they succeed not because of the merits of their religion but because of the science-based technology for which it is pardonably, but wrongly, given credit.

Surely the Christian God must be superior to our Juju, because Christ’s representatives come bearing rifles, telescopes, chainsaws, radios, almanacs that predict eclipses to the minute, and medicines that work.

So much for cultural relativism. A different type of truth-heckler prefers to drop the name of Karl Popper or (more fashionably) Thomas Kuhn:

There is no absolute truth. Your scientific truths are merely hypotheses that have so far failed to be falsified, destined to be superseded. At worst, after the next scientific revolution, today’s ‘truths’ will seem quaint and absurd, if not actually false. The best you scientists can hope for is a series of approximations which progressively reduce errors but never eliminate them.

The Popperian heckle partly stems from the accidental fact that philosophers of science are obsessed with one piece of scientific history: the comparison between Newton’s and Einstein’s theories of gravitation. It is true that Newton’s simple inverse square law has turned out to be an approximation, a special case of Einstein’s more general formula. If this is the only piece of scientific history you know, you might indeed conclude that all apparent truths are mere approximations, fated to be superseded. There is even a quite interesting sense in which all our sensory perceptions – the ‘real’ things that we ‘see with our own eyes’, may be regarded as unfalsified ‘hypotheses’ about the world, vulnerable to change. This provides a good way to think about illusions, such as the Necker Cube.

The flat pattern of ink on paper is compatible with two alternative ‘hypotheses’ of solidity. So we see a solid cube which, after a few seconds, ‘flips’ to a different cube, then flips back to the first cube, and so on. Perhaps sense data only ever confirm or reject mental ‘hypotheses’ about what is out there.

Well, that is an interesting theory; so is the philosopher’s notion that science proceeds by conjecture and refutation; and so is the analogy between the two. This line of thought – all our percepts are hypothetical models in the brain – might lead us to fear some future blurring of the distinction between reality and illusion in our descendants, whose lives will be even more dominated by computers capable of generating vivid models of their own. Without venturing into the high-tech worlds of virtual reality, we already know that our senses are easily deceived. Conjurors – professional illusionists – can persuade us, if we lack a skeptical foothold in reality, that something supernatural is going on. Indeed some notorious erstwhile conjurors make a fat living doing exactly that: a living much fatter than they ever enjoyed when they frankly admitted that they were conjurors. Scientists, alas, are not best equipped to unmask telepathists, mediums and spoonbending charlatans. This is a job which is best handed over to the professionals, and that means other conjurors. The lesson that conjurors, the honest variety and the impostors, teach us is that an uncritical faith in our own sense organs is not an infallible guide to truth.

But none of this seems to undermine our ordinary concept of what it means for something to be true. If I am in the witness box, and prosecuting counsel wags his stern finger and demands, “Is it or is it not true that you were in Chicago on the night of the murder,” I should get pretty short shrift if I said,

What do you mean by true? The hypothesis that I was in Chicago has not so far been falsified, but it is only a matter of time before we see that it is a mere approximation.

Or, reverting to the first heckle, I would not expect a jury, even a Bongolese jury, to give a sympathetic hearing to my plea that,

It is only in your western scientific sense of the word ‘in’ that I was in Chicago. The Bongolese have a completely different concept of ‘in’, according to which you are only truly ‘in’ a place if you are an anointed elder entitled to take snuff from the dried scrotum of a goat.

It is simply true that the Sun is hotter than Earth, true that the desk on which I am writing is made of wood. These are not hypotheses awaiting falsification; not temporary approximations to an ever-elusive truth; not local truths that might be denied in another culture. They are just plain true. And the same can safely be said of most scientific truths. It is forever true that DNA is a double helix, true that if you and a chimpanzee (or an octopus or a kangaroo) trace your ancestors back far enough you will eventually hit a shared ancestor. To a pedant, these are still hypotheses which might be falsified tomorrow. But they never will be. Strictly, the truth that there were no human beings in the Jurassic era is still a conjecture, which could be refuted at any time by the discovery of a single fossil, authentically dated by a battery of radiometric methods. It could happen. Want a bet? These are just truths, even if they are nominally hypotheses on probation. They are true in exactly the same sense as the ordinary truths of everyday life; true in the same sense as it is true that you have a head, and that my desk is wooden. If scientific truth is open to philosophic doubt, it is no more so than common sense truth. Let’s at least be even-handed in our philosophical heckling.

A more profound difficulty now arises for our scientific concept of truth. Science is very much not synonymous with common sense. Admittedly, that doughty scientific hero T H Huxley said:

Science is nothing but trained and organized common sense, differing from the latter only as a veteran may differ from a raw recruit: and its methods differ from those of common sense only as far as the guardsman's cut and thrust differ from the manner in which a savage wields his club.

But Huxley was talking about the methods of science, not its conclusions. As Lewis Wolpert emphasised in The Unnatural Nature of Science, the conclusions can be disturbingly counter-intuitive. Quantum theory is counter-intuitive to the point where the physicist sometimes seems to be battling insanity. We are asked to believe that a single quantum behaves like a particle in going through one hole instead of another, but simultaneously behaves like a wave in interfering with a non-existent copy of itself, if another hole is opened through which that non-existent copy could have traveled (if it had existed). It gets worse, to the point where some physicists resort to a vast number of parallel but mutually unreachable worlds, which proliferate to accommodate every alternative quantum event; while other physicists, equally desperate, suggest that quantum events are determined retrospectively by our decision to examine their consequences. Quantum theory strikes us as so weird, so defiant of common sense, that even the great physicist Richard Feynman was moved to remark, "I think I can safely say that nobody understands quantum mechanics." Yet the many predictions by which quantum theory has been tested stand up, with an accuracy so stupendous that Feynman compared it to measuring the distance between New York and Los Angeles accurately to the width of one human hair. On the basis of these stunningly successful predictions, quantum theory, or some version of it, seems to be as true as anything we know.

Modern physics teaches us that there is more to truth than meets the eye; or than meets the all too limited human mind, evolved as it was to cope with medium sized objects moving at medium speeds through medium distances in Africa. In the face of these profound and sublime mysteries, the low-grade intellectual poodling of pseudo-philosophical poseurs seems unworthy of adult attention.

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How do you wear your genes?

by Richard Dawkins

Article in Evening Standard Online April 3, 2000

Scarcely a day goes by without the papers breaking the news of some dramatic new gene. It's always described as a gene "for" some very specific thing. A gene for religion, a gene for sodomy or a gene for skill in tying shoelaces.

I made those examples up, but everyone is familiar with the kind of thing I mean. I want to explain why it's easy to be misled by such language. I also want to explain what "gene for" really means. I have deliberately chosen examples that are psychological or behavioural, and heavily influenced by culture, (as opposed to, say, " gene for haemophilia", or "gene for colour blindness", whose effects are entirely physical).

You can easily translate "gene for religion" as "gene for developing the kind of brain that is predisposed to religion when exposed to a religious culture". "Gene for skill tying shoelaces" will show itself as such only in a culture where there are shoelaces to be tied.

In another culture the same gene - which would really be responsible for a more general manual dexterity - might show itself as, say, a "gene for skills in making traditional fishing nets" or a "gene for making efficient rabbit snares". I'll come back to the more controversial idea of "a gene for sodomy" later.

First, there is a quite separate difficulty. Many people make a hidden, and quite wrong, assumption of a one-to-one mapping between single genes and single effects. We shall see in a moment that it is almost never really like that. Another equally wrong assumption is that genetic effects are inevitable and inescapable. Often, all they do is change statistical probabilities.

Cigarettes can give you cancer. So can genes. We'd expect insurance actuaries to be interested in both. We all know the cigarette effect isn't inevitable: heavy smokers sometimes reach an advanced age before dying of something else. Smoking just increases the probability of dying of cancer. Genes are like cigarettes. They, too, change probabilities. They (usually) don't determine your fate absolutely.

Some people find the following analogy helpful. Imagine a bedsheet hanging by rubber bands from 1,000 hooks in the ceiling. The rubber bands don't hang neatly but instead form an intricate tangle above the roughly horizontal sheet.

The shape in which the sheet hangs represents the body - including the brain, and therefore psychological dispositions to respond in particular ways to various cultural environments. The tensions up at the hooks represent the genes. The environment is represented by strings coming in from the side, tugging sideways on the rubber bands in various directions.

The point of the analogy is that, if you cut one rubber band from its hook - equivalent to changing ("mutating") one gene - you don't change just one part of the sheet. You re-balance the tensions in the whole tangled mess of rubber bands, and therefore the shape of the whole sheet. If the web of criss-crossing rubber bands and strings is complex enough, changing any one of them could cause a lurching shift in tensions right across the network.

A gene doesn't zero in on one single bit of the body, or one psychological element. It affects the way other genes affect the way... and so on. A gene has many effects. We label it by a conspicuous one that we notice.

The genes are sometimes described as a blueprint, but they are nothing like a blueprint. There is one-to-one mapping between a house and its blueprint. If I point to a spot in a house, you can go straight to that unique spot on the blueprint.

You can't do that with a body. If I prick a particular point, say on the back of your hand, there is no single spot in your set of genes corresponding to that point. If the genes are not a blueprint, what are they? A favourite simile is a recipe, where the body is a cake. There is no one-to-one mapping between words of the recipe, and crumbs of the final cake. All the sentences in the whole recipe, if executed in the proper sequence, make a whole cake. For a baby to develop, a complicated genetic recipe has to be followed, with the right genes turning each other on in the right sequence, and interacting with the right environmental triggers.

Given such a complicated recipe, with lots of participating genes, a simple change of a single gene can cause an apparently complicated change in the way the brain ends up behaving - just as a key change of one word in a recipe can produce an interestingly different cake.

Now let's look at the hypothetical "gene for sodomy" again. Homosexual desire might seem too complicated to be put down to a single gene. But the implausibility dissolves when you realise we are talking about a change of a single gene, in an already complicated cascade of multi-gene influences.

In order to have its particular effect, such a gene needs make only a small modification in an existing brain mechanism, the mechanism that gives us our normal heterosexual desires. And that mechanism will have been put together by a consortium of co-operating genes, favoured over millions of years of Darwinian selection.

The problem as far as public perceptions are concerned, is that, if a gene for sodomy were discovered, people might simply assume that its effects would be as inevitable on an individual as, say, a gene for haemophilia.

In fact there is no way of telling, in advance, whether a gene for sodomy would be like haemophilia in being inevitable, or like shoelace-tying in being culture-dependent, or like cigarettes in being a matter of probabilities.

It is worth bearing this in mind next time you read of a newlydiscovered "gene for X". It will almost certainly be a much less momentous discovery than it sounds and it correspondingly should be less alarming - and less controversial.

How we got a head start on our animal natures

How we got a head start on our animal natures, - Our selfish genes made brains that turned the tables on them--The Sunday Times Dec 29, 1996

Do we need God to be good? The question means two very different things. First, does religion provide an explanation for why we are good (to the extent that we are)? Second, do we need the inducements and threats, the carrots and sticks, the heavens and hells, that God can offer, in order to persuade us to be good? A similar ambiguity arises about science. Can science explain why we have impulses to be good? And can it advise us what is a good thing to do?

If you must use Darwinism as a morality play, treat it as an awful warning. For this reason I have sometimes jokingly put myself in the vanguard of a passionate anti-Darwinism movement. Nature really is red in tooth and claw. The weakest really do go to the wall, and natural selection really does favour selfish genes. The racing elegance of cheetahs and gazelles is bought at huge cost in blood and suffering of generations of ancestors on both sides. The end product of natural selection, life in all its forms, is beautiful and rich. But the process is vicious, brutal and short-sighted.

As an academic fact we know that we are Darwinian creatures, our forms and our brains carved into shape by natural selection, that indifferent, blind old sculptor. But this doesn't mean we have to like it. On the contrary, a Darwinian society is not a society in which any friend of mine would wish to live. Darwinian is not a bad definition of precisely the sort of politics I would run a hundred miles not to be governed by, a sort of over-the-top Thatcherism gone native. I should be allowed a personal word here, because I am tired of being identified with a bleak politics of ruthless competitiveness. I still reel at the memory of an article titled "The Thatcher view of human nature" in the New Scientist in May 1979, which all but accused "selfish genery" of responsibility for the Iron Lady's recent election! Similar accusations recur to the present day.

Simplistic (for once the word is appropriate) analysts see only a continuum being hard and soft, nasty and nice, selfish and altruistic. Each of us, on this view, sits at some point along the spectrum. Perhaps there is a linear spectrum in politics, in which case I think I am at the soft end. Scientifically, I suppose I seem ultra-hard, but actually Darwinian theories should not be classified along a hard/soft spectrum at all. Instead, they disagree about where, in the hierarchy of life, natural selection acts.

Does it choose among individuals (Darwin's view), groups or species (the view of many of Darwin's lesser successors), or among units at some other level? I am associated with the view that natural selection chooses among alternative genes. But this does not, as we shall see, cash out as a necessarily hard or soft position.

Baroness Thatcher is, of course, tame compared with the Social Darwinists and other enthusiasts of the early 20th century. Listen to H G Wells's utopian vision (and he was supposed to be socialist) of The New Republic: "The theory of natural selection . . . has destroyed, quietly but entirely, the belief in human equality which is implicit in all the 'liberalising' movements of the world . . . It has become apparent that the whole masses of human population are, as a whole, inferior in their claim upon the future."

It is stuff like this (and there's lots more from Wells's contemporaries) that tempts one to lead a crusade against Darwinism. But it is better not to use the facts of nature to derive our politics or our morality one way or the other. I prefer to side with the philosopher David Hume: moral directives cannot be derived from descriptive premises or, put colloquially, "You can't get an 'ought' from an 'is'." Where, then, on the evolutionary view, do our "oughts" come from? Why are you and I so much nicer than our selfish genes ever programmed us to be?

The problem is not as acute as it might naively appear. Genes may be selfish, but this is far from saying that individual organisms must be selfish. A large purpose of the doctrine of the selfish gene is to explain how selfishness at gene level can lead to altruism at the level of the individual organism. But that only covers altruism as a kind of selfishness in disguise: first, altruism towards kin (nepotism); second, boons given in the expectation of reciprocation (you play ball with me and I'll repay you later).

I think that, uniquely in the animal kingdom, we make good use of the priceless gift of foresight. Contrary to popular misunderstandings of it, Darwinian natural selection has no foresight. It couldn't have, for DNA is just a molecule and molecules cannot think. If they could, they would have seen the danger presented by contraception which means we still enjoy sex, even though the original genetic consequence of it has been subverted and nipped it in the bud long ago. But brains are another matter.

Brains, if they are big enough, can run all sorts of hypothetical scenarios through their imaginations and calculate the consequences of alternative courses of action. If I do such-and-such I'll gain in the short term. But if I do so-and-so, although I'll have to wait for my reward, it'll be bigger when it comes. Ordinary evolution by natural selection, although it seems such a powerful force for technical improvement, cannot look ahead in this way.

Our brains were endowed with the facility to set up goals and purposes. Originally, these goals would have been strictly in the service of gene survival: the goal of killing a buffalo, finding a new waterhole, kindling a fire, and so on. Still in the interest of gene survival, it was an advantage to make these goals as flexible as possible. New brain machinery, capable of deploying a hierarchy of reprogrammable subgoals within goals, started to evolve. Skin an animal to roof a shelter to keep wood dry so that, in the future, you will be able to light a fire to scare away the terrible sabretooth.

Imaginative forethought of this kind was originally useful but (in the genes' eye view) it got out of hand. Brains as big as ours can actively rebel against the dictates of the naturally selected genes that built them. Using language, that other unique gift of the big human brain, we can conspire together and devise political institutions, systems of law and justice, taxation, policing, public welfare, charity, care for the elderly and disadvantaged. Such ideals and institutions are too forward-looking for natural selection to achieve, unaided. Natural selection can give rise to them, at second remove, by making brains that grow big. From the point of view of the selfish genes, our brains got out of hand and that is our saving grace.

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Human Chauvinism

by Richard Dawkins: Review of Full House by Stephen Jay Gould (New York: Harmony Books, 1996; also published as Life's Grandeur by Jonathan Cape, London). In Evolution (Vol. 51 June 1997 No. 3)

This pleasantly written book has two related themes. The first is a statistical argument which Gould believes has great generality, uniting baseball, a moving personal response to the serious illness from which, thankfully, the author has now recovered, and his second theme: that of whether evolution is progressive. The argument about evolution and progress is interesting – though flawed as I shall show – and will occupy most of this review. The general statistical argument is correct and mildly interesting, but no more so than several other homilies of routine methodology about which one could sensibly get a bee in one's bonnet.

Gould's modest and uncontroversial statistical point is simply this. An apparent trend in some measurement may signify nothing more than a change in variance, often coupled with a ceiling or floor effect. Modern baseball players no longer hit a 0.400 (whatever that might be – evidently it is something pretty good). But this doesn't mean they are getting worse. Actually everything about the game is getting better and the variance is getting less. The extremes are being squeezed and 0.400 hitting, being an extreme, is a casualty. The apparent decrease in batting success is a statistical artefact, and similar artefacts dog generalisations in less frivolous fields.

That didn't take long to explain, but baseball occupies 55 jargon-ridden pages of this otherwise lucid book and I must enter a mild protest on behalf of those readers who live in that obscure and little known region called the rest of the world. I invite Americans to imagine that I spun out a whole chapter in the following vein:

"The home keeper was on a pair, vulnerable to anything from a yorker to a chinaman, when he fell to a googly given plenty of air. Silly mid on appealed for leg before, Dicky Bird's finger shot up and the tail collapsed. Not surprisingly, the skipper took the light. Next morning the night watchman, defiantly out of his popping crease, snicked a cover drive off a no ball straight through the gullies and on a fast outfield third man failed to stop the boundary . . ." etc. etc.

Readers in England, the West Indies, Australia, New Zealand, India, Pakistan, Sri Lanka and anglophone Africa would understand every word, but Americans, after enduring a page or two, would rightly protest.

Gould's obsession with baseball is harmless and, in the small doses to which we have hitherto been accustomed, slightly endearing. But this hubristic presumption to sustain readers' attention through six chapters of solid baseball chatter amounts to American chauvinism (and I suspect American male chauvinism at that). It is the sort of self-indulgence from which an author should have been saved by editor and friends before publication – and for all I know they tried. Gould is normally so civilised in his cosmopolitan urbanity, so genial in wit, so deft in style. This book has a delightfully cultivated yet unpretentious 'Epilog on Human Culture' which I gratefully recommend to anyone, of any nation. He is so good at explaining science without jargon yet without talking down, so courteous in his judgement of when to spell out, when to flatter the reader by leaving just a little unsaid. Why does his gracious instinct desert him when baseball is in the air?

Another minor plaint from over the water, this time something which is surely not Dr Gould's fault: may I deplore the growing publishers' habit of gratuitously renaming books when they cross the Atlantic (both ways)? Two of my colleagues are are at risk of having their (excellent, and already well-named) books retitled, respectively, "The Pelican's Breast" and "The Pony Fish's Glow" (now what, I wonder, can have inspired such flights of derivative imagination?) As one embattled author wrote to me, "Changing the title is something big and important they can do to justify their salaries, and it does not require reading the book, so that's why they like it so much." In the case of the book under review, if the author's own title, Full House, is good enough for the American market, why is the British edition masquerading under the alias of Life's Grandeur? Are we supposed to need protection from the argot of the card table?

At the best of times such title changes are confusing and mess up our literature citations. This particular change is doubly unfortunate because Life's Grandeur (the title, not the book) is tailor-made for confusion with Wonderful Life, and nothing about the difference between the titles conveys the difference between the contents. The two books are not Tweedledum and Tweedledee, and it is unfair on their author to label them as if they were. More generally, may I suggest that authors of the world unite and assert their right to name their own books.

Enough of carping. To evolution: is it progressive? Gould's definition of progress is a human-chauvinistic one which makes it all too easy to deny progress in evolution. I shall show that if we use a less anthropocentric, more biologically sensible, more 'adaptationist' definition, evolution turns out to be clearly and importantly progressive in the short to medium term. In another sense it is probably progressive in the long term too.

Gould's definition of progress, calculated to deliver a negative answer to the question whether evolution is progressive, is "a tendency for life to increase in anatomical complexity, or neurological elaboration, or size and flexibility of behavioral repertoire, or any criterion obviously concocted (if we would only be honest and introspective enough about our motives) to place Homo sapiens atop a supposed heap." My alternative, 'adaptationist' definition of progress is "a tendency for lineages to improve cumulatively their adaptive fit to their particular way of life, by increasing the numbers of features which combine together in adaptive complexes." I'll defend this definition and my consequent, limited, progressivist conclusion, later.

Gould is certainly right that human chauvinism, as an unspoken motif, runs through a great deal of evolutionary writing. He'll find even better examples if he looks at the comparative psychology literature, which is awash with snobbish and downright silly phrases like 'subhuman primates', 'subprimate mammals' and 'submammalian vertebrates', implying an unquestioned ladder of life defined so as to perch us smugly on the top rung. Uncritical authors regularly move 'up' or 'down' the 'evolutionary scale' (bear in mind that they are in fact moving among modern animals, contemporary twigs dotted all around the tree of life). Students of comparative mentality unabashedly and ludicrously ask, 'How far down the animal kingdom does learning extend?' Volume 1 of Hyman's celebrated treatise on the invertebrates is entitled 'Protozoa through Ctenophora' (my emphasis) – as if the phyla exist along an ordinal scale such that everybody knows which groups sit 'between' Protozoa and Ctenophora. Unfortunately all zoology students do know – we've all been taught the same groundless myth.

This is bad stuff, and Gould could afford to attack it even more severely than he attacks his normal targets. Whereas I would do so on logical grounds (Dawkins, 1992), Gould prefers an empirical assault. He looks at the actual course of evolution and argues that such apparent progress as can in general be detected is artefactual (like the baseball statistic). Cope's rule of increased body size, for example, follows from a simple 'drunkard's walk' model. The distribution of possible sizes is confined by a left wall, a minimal size. A random walk from a beginning near the left wall has nowhere to go but up the size distribution. The mean size has pretty well got to increase, and it doesn't imply a driven evolutionary trend towards larger size.

As Gould convincingly argues, the effect is compounded by a human tendency to give undue weight to new arrivals on the geological scene. Textbook biological histories emphasise a progression of grades of organization. As each new grade arrives, there is temptation to forget that the previous grades haven't gone away. Illustrators abet the fallacy when they draw, as representative of each era, only the newcomers. Before a certain date there were no eucaryotes. The arrival of eucaryotes looks more progressive than it really was because of the failure to depict the persisting hordes of procaryotes. The same false impression is conveyed with each new arrival on the stage: vertebrates, large brained animals, and so on. An era may be described as the 'Age of Xs' – as though the denizens of the previous 'Age' had been replaced rather than merely supplemented.

Gould drives his point home with an admirable section on bacteria. For most of history, he reminds us, our ancestors have been bacteria. Most organisms still are bacteria, and a serviceable case can be made that most contemporary biomass is bacterial. We eucaryotes, we large animals, we brainy animals, are a recent wart on the face of a biosphere which is still fundamentally, and predominantly, procaryotic. To the extent that average size / complexity / cell number / brain size has increased since the 'age of bacteria', this could be simply because the wall of possibilities constrains the drunkard from moving in any other direction. John Maynard Smith recognized this possibility but doubted it when he considered the matter in 1970:

> The obvious and uninteresting explanation of the evolution of increasing complexity is that the first organisms were necessarily simple . . . And if the first organisms were simple, evolutionary change could only be in the direction of complexity.

Maynard Smith suspected that there was more to be said than this 'obvious and uninteresting explanation', but he didn't go into detail. Perhaps he was thinking of what he later came to term The Major Transitions in Evolution (Maynard Smith and Szathm‡ry, 1995), or what I have called 'The Evolution of Evolvability'

(Dawkins 1989).

Gould’s empirical treatment follows McShea (1996), whose definition of complexity is reminiscent of J W S Pringle’s (1951); also of Julian Huxley’s (1912) definition of ‘individuality’ as ‘heterogeneity of parts’. Pringle called complexity an epistemological concept, meaning a measure applied to our description of something rather than to that something itself. A crab is morphologically more complex than a millipede because, if you wrote a pair of books describing each animal down to the same level of detail, the crab book would have a higher word-count than the millipede book. The millipede book would describe a typical segment then simply add that, with listed exceptions, the other segments are the same. The crab book would require a separate chapter for each segment and would therefore have a higher information content. McShea applied a similar notion to the vertebral column, expressing complexity in terms of heterogeneity among vertebrae.

With his measure of complexity in place, McShea sought statistical evidence for any general tendency for it to increase in fossil lineages. He made a distinction between passive trends (Gould’s statistical artefacts) and driven trends (a true bias towards increased complexity, presumably driven by natural selection). By Gould’s enthusiastic account, he concluded that there is no general evidence that a statistical majority of evolutionary lineages show driven trends in the direction of increased complexity. Gould goes further, pointing out that since so many species are parasites and parasite lineages commonly favour decreased complexity, there may even be a statistical trend in the opposite direction to the one hypothesized.

Gould is sailing dangerously close to the windmill tilting that he has previously made his personal art form. Why should any thoughtful Darwinian have expected a majority of lineages to increase in anatomical complexity? Certainly it is not clear that anybody inspired by adaptationist philosophy would. Admittedly people inspired by human vanity might (and historically Gould is right that many have fallen for this vice). Our human line happens to have specialised in complexity, especially of the nervous system, so it is only human that we should define progress as an increase in complexity or in braininess. Other species will see it differently, as Julian Huxley (1926) pointed out in a piece of doggerel entitled Progress:-

> The Crab to Cancer junior gave advice:
> ‘Know what you want, my son, and then proceed
> Directly sideways. God has thus decreed –
> Progress is lateral; let that suffice’.
>
> Darwinian Tapeworms on the other hand
> Agree that Progress is a loss of brain,
> And all that makes it hard for worms to attain
> The true Nirvana – peptic, pure and grand.
>
> Man too enjoys to omphaloscopize.
> Himself as Navel of the Universe . . .

The poetry is not great (I couldn’t bear to copy out the ending), and there is a confusion of timescales between the crab verse (behavioral time) and the tapeworm verse (evolutionary time), but an important point lurks here. Gould uses a human-chauvinistic definition of progress, measuring it in terms of complexity. This was why he was able to use parasites as ammunition against progress. Huxley’s tapeworms, using a parasite-centred definition of progress, see the point with opposite sign. A statistically minded swift would search in vain for evidence that a majority of evolutionary lineages show trends towards improved flying performance. Learned elephants, to borrow a pleasantry from Steven Pinker (1994), would ruefully fail to uphold the comforting notion that progress, defined as a driven elongation of the nose, is manifested by a statistical majority of animal lineages.

This may seem a facetious point but that is far from my intention. On the contrary, it goes to the heart of my adaptationist definition of progress. This, to repeat, takes progress to mean an increase, not in complexity, intelligence or some other anthropocentric value, but in the accumulating number of features contributing towards whatever adaptation the lineage in question exemplifies. By this definition, adaptive evolution is not just incidentally progressive, it is deeply, dyed-in-the wool, indispensably progressive. It is fundamentally necessary that it should be progressive if Darwinian natural selection is to perform the explanatory role in our world view that we require of it, and that it alone can perform. Here’s why.

Creationists love Sir Fred Hoyle's vivid metaphor for his own misunderstanding of natural selection. It is as if a hurricane, blowing though a junkyard, had the good fortune to assemble a Boeing 747. Hoyle's point is about statistical improbability. Our answer, yours and mine and Stephen Gould's, is that natural selection is cumulative. There is a ratchet, such that small gains are saved. The hurricane doesn't spontaneously assemble the airliner in one go. Small improvements are added bit by bit. To change the metaphor, however daunting the sheer cliffs that the adaptive mountain first presents, graded ramps can be found the other side and the peak eventually scaled. Adaptive evolution must be gradual and cumulative, not because the evidence supports it (though it does) but because nothing except gradual accumulation could, in principle, do the job of solving the 747 riddle. Even divine creation wouldn't help. Quite the contrary since any entity complicated and intelligent enough to perform the creative rôle would itself be the ultimate 747. And for exactly the same reason the evolution of complex, many-parted adaptations must be progressive. Later descendants will have accumulated a larger number of components towards the adaptive combination than earlier ancestors.

The evolution of the vertebrate eye must have been progressive. Ancient ancestors had a very simple eye, containing only a few features good for seeing. We don't need evidence for this (although it is nice that it is there). It has to be true because the alternative – an initially complex eye, well-endowed with features good for seeing – pitches us right back to Hoyle country and the sheer cliff of improbability. There must be a ramp of step-by-step progress towards the modern, multifeatured descendant of that optical prototype. Of course, in this case, modern analogs of every step up the ramp can be found, working serviceably in dozens of eyes dotted independently around the animal kingdom. But even without these examples, we could be confident that there must have been a gradual, progressive increase in the number of features which an engineer would recognize as contributing towards optical quality. Without stirring from our armchair, we can see that it must be so.

Darwin himself understood this kind of argument clearly, which is why he was such a staunch gradualist. Incidentally, it is also why Gould is unjust when he implies, not in this book but in many other places, that Darwin was against the spirit of punctuationism. The theory of punctuated equilibrium itself is gradualist (by Gad it had better be) in the sense in which Darwin was a gradualist – the sense in which all sane evolutionists must be gradualists, at least where complex adaptations are concerned. It is just that, if punctuationism is right, the progressive, gradualistic steps are compressed into a timeframe which the fossil record does not resolve. Gould admits this when pressed, but he isn't pressed often enough.

Mark Ridley quotes Darwin on orchids, in a letter to Asa Gray: "It is impossible to imagine so many co-adaptations being formed all by a chance blow". As Ridley (1982) goes on, "The evolution of complex organs had to be gradual because all the correct changes would not occur in a single large mutation." And gradual, in this context, needs to mean progressive in my 'adaptationist' sense. The evolution of anything as complex as an advanced orchid was progressive. So was the evolution of echolocation in bats and river dolphins – progressive over many many steps. So was the evolution of electrolocation in fish, and of skull dislocation in snakes for swallowing large prey. So was the evolution of the complex of adaptations that equips cheetahs to kill, and the corresponding complex that equips gazelles to escape.

Indeed, as Darwin again realised although he did not use the phrase, one of the main driving forces of progressive evolution is the coevolutionary arms race, such as that between predators and their prey. Adaptation to the weather, to the inanimate vicissitudes of ice ages and droughts, may well not be progressive: just an aimless tracking of unprogressively meandering climatic variables. But adaptation to the biotic environment is likely to be progressive because enemies, unlike the weather, themselves evolve (Vermeij, 1987). The resulting positive feedback loop is a good explanation for driven progressive evolution, and the drive may be sustained for many successive generations. The participants in the race do not necessarily survive more successfully as time goes by – their 'partners' in the coevolutionary spiral see to that (the familiar Red Queen Effect). But the equipment for survival, on both sides, is improving as judged by engineering criteria. In hard fought examples we may notice a progressive shift in resources from other parts of the animal's economy to service the arms race (Dawkins & Krebs, 1979). And in any case the improvement in equipment will normally be progressive. Another kind of positive feedback in evolution, if R A Fisher and his followers are right, results from the linkage disequilibrium generated by sexual selection (Arnold 1983). Once again, progressive evolution is the expected consequence.

Progressive increase in morphological complexity is to be expected only in taxa whose way of life benefits from morphological complexity. Progressive increase in brain size is to be expected only in animals where braininess is an advantage. This may, for all I know, constitute a minority of lineages. But what I do insist is that in a majority of evolutionary lineages there will be progressive evolution towards something. It won't, however, be the same thing in different lineages (this was the point about swifts and elephants). And there is no general reason to expect a majority of lineages to progress in the directions pioneered by our human line.

But have I now defined progress so generally as to make it a blandly useless word? I don't think so. To say that the evolution of the vertebrate eye was progressive is to say something quite strong and quite important. If you could lay out all the intermediate ancestors in chronological order you'd find that, first, for a majority of dimensions of measurement, the changes would be transitive over the whole sequence. That is, if A is ancestral to B which is ancestral to C, the direction of change from A to B is likely to be the same as the direction of change from B to C. Second, the number of successive steps over which progress is seen is likely to be large: the transitive series extends beyond A, B and C, far down the alphabet. Third, an engineer would judge the performance to have improved over the sequence. Fourth, the number of separate features combining and conspiring to improve performance would increase. Finally, this kind of progress really matters because it is the key to answering the Hoyle challenge. There will be exceptional reversals, for instance in the evolution of blind cave fish where eyes degenerate because they are not used and are costly to make. And there will doubtless be periods of stasis where there is no evolution at all, progressive or otherwise.

To conclude this point. Gould is wrong to say that the appearance of progress in evolution is a statistical illusion. It does not result just from a change in variance as a baseball-style artefact. To be sure, complexity, braininess and other particular qualities dear to the human ego should not necessarily be expected to increase progressively in a majority of lineages – though it would be interesting if they did: the investigations of McShea, Jerison (1973) and others are not a waste of time. But if you define progress less chauvinistically – if you let the animals bring their own definition – you will find progress, in a genuinely interesting sense of the word, nearly everywhere.

Now it is important to stress that, on this adaptationist view (unlike the 'evolution of evolvability' view to be discussed shortly), progressive evolution is to be expected only on the short to medium term. Coevolutionary arms races may last for millions of years but probably not hundreds of millions. Over the very long timescale, asteroids and other catastrophes bring evolution to a dead stop, major taxa and entire radiations go extinct. Ecological vacuums are created, to be filled by new adaptive radiations driven by new ranges of arms races. The several arms races between carnivorous dinosaurs and their prey were later mirrored by a succession of analogous arms races between carnivorous mammals and their prey. Each of these successive and separate arms races powered sequences of evolution which were progressive in my sense. But there was no global progress over the hundreds of millions of years, only a sawtooth succession of small progresses terminated by extinctions. Nonetheless, the ramp phase of each sawtooth was properly and significantly progressive.

Ironically for such an eloquent foe of progress, Gould flirts with the idea that evolution itself changes over the long haul, but he puts it in a topsy turvy way which has undoubtedly been widely misleading. It is more fully expounded in Wonderful Life but reprised in the present book. For Gould, evolution in the Cambrian was a different kind of process from evolution today. The Cambrian was a period of evolutionary 'experiment', evolutionary 'trial and error', evolutionary 'false starts'. It was a period of 'explosive' invention, before evolution stabilised into the humdrum process we see today. It was the fertile time when all the great 'fundamental body plans' were invented. Nowadays, evolution just tinkers with old body plans. Back in the Cambrian, new phyla and new classes arose. Nowadays we only get new species!

This may be a slight caricature of Gould's own considered position, but there is no doubt that the many American nonspecialists who unfortunately, as Maynard Smith (1995) wickedly observes, get their evolutionary knowledge almost entirely from Gould, have been deeply misled. Admittedly what follows is an extreme example, but Daniel Dennett has recounted a conversation with a philosopher colleague who read Wonderful Life as arguing that the Cambrian phyla did not have a common ancestor – that they had sprung up as independently initiated life forms! When Dennett assured him that this was not Gould's claim, his colleague's response was "Well then, what is all the fuss about?"

Even some professional evolutionists have been inspired by Gould's rhetoric into committing some pretty remarkable solecisms. Leakey and Lewin's The Sixth Extinction (1996) is an excellent book except for its Chapter 3, 'The Mainspring of Evolution', which is avowedly heavily influenced by Gould. The following quotations from that chapter could hardly be more embarrassingly explicit:-

"Why haven't new animal body plans continued to crawl out of the evolutionary cauldron during the past hundreds of millions of years?"

"In early Cambrian times, innovations at the phylum level survived because they faced little competition."

"Below the level of the family, the Cambrian explosion produced relatively few species, whereas in the post-Permian a tremendous species diversity burgeoned. Above family level however, the post-Permian radiation faltered, with few new classes and no new phyla being generated. Evidently, the mainspring of evolution operated in both periods, but it propelled greater extreme experimentation in the Cambrian than in the post-Permian, and greater variations on existing themes in the post-Permian."

"Hence, evolution in Cambrian organisms could take bigger leaps, including phylum-level leaps, while later on it would be more constrained, making only modest jumps, up to the class level."

It is as though a gardener looked at an old oak tree and remarked, wonderingly: "Isn't it strange that no major new boughs have appeared on this tree for many years. These days, all the new growth appears to be at the twig level!"

As it happens, recent molecular clock evidence indicates that the 'Cambrian Explosion' may never have happened. Far from the major phyla diverging from a point at the beginning of the Cambrian, Wray, Levinton and Shapiro (1996) present evidence that the common ancestors of the major phyla are staggered through hundreds of millions of years back in the Precambrian. But never mind that. That is not the point I want to make. Even if there really was a Cambrian explosion such that all the major phyla diverged during a ten million year period, this is no reason to think that Cambrian evolution was a qualitatively special kind of super-jumpy process. Baupläne don't drop out of a clear Platonic sky, they evolve step by step from predecessors, and they do so (I bet, and so would Gould if explicitly challenged) under approximately the same Darwinian rules as we see today.

"Phylum-level leaps" and "modest jumps, up to the class level" are the sheerest nonsense. Jumps above the species level don't happen, and nobody who thinks about it for two minutes claims that they do. Even the great phyla, when they originally bifurcated one from another, were just pairs of new species, members of the same genus. Classes are species that diverged a very long time ago, and phyla are species that diverged an even longer time ago. Indeed it is a moot – and rather empty – question precisely when in the course of the step by step, gradual mutual divergence of, say, mollusc ancestors and annelid ancestors after the time when they were congeneric species, we should wish to say that the divergence had reached 'Bauplan' status. A good case could be made that The Bauplan is a myth, probably as pernicious as any of the myths that Stephen Gould has so ably combatted, but this one, in its modern form, is largely perpetuated by him.

I return, finally, to the 'evolution of evolvability' and a very real sense in which evolution itself may evolve, progressively, over a longer timescale than the individual ramps of the arms race sawtooth. Notwithstanding Gould's just scepticism over the tendency to label each era by its newest arrivals, there really is a good possibility that major innovations in embryological technique open up new vistas of evolutionary possibility and that these constitute genuinely progressive improvements (Dawkins 1989; Maynard Smith & Szathm‡ry 1995). The origin of the chromosome, of the bounded cell, of organized meiosis, diploidy and sex, of the eucaryotic cell, of multicellularity, of gastrulation, of molluscan torsion, of segmentation – each of these may have constituted a watershed event in the history of life. Not just in the normal Darwinian sense of assisting individuals to survive and reproduce, but watershed in the sense of boosting evolution itself in ways that seem entitled to the label progressive. It may well be that after, say, the invention of multicellularity, or the invention of metamerism, evolution was never the same again. In this sense there may be a one-way ratchet of progressive innovation in evolution.

For this reason over the long term, and because of the cumulative character of coevolutionary arms races over the shorter term, Gould's attempt to reduce all progress to a trivial, baseball-style artefact constitutes a surprising impoverishment, an uncharacteristic slight, an unwonted demeaning of the richness of evolutionary processes.

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Home

Human gullibility beyond belief, - the "paranormal" in the media--The Sunday Times Aug 25, 1996

Article in The Sunday Times August 25, 1996

Hello, good evening and welcome. I have paranormal, psychic powers. I can go on prime-time live television and make somebody vomit, by remote teleportation of what we call psychonauseous energy. Here in the studio 1 have a map of Britain. I am going to breathe on a particular part of the country - let's say here, over the Pennines. Now, you people out there, I want you to telephone if anything strange happens during the programme.

It would not be long before the first phone call came in.

Caller:---My lad has just sicked up his tea and there's ketchup all over the sofa.--

Knighted presenter: -Amazing, astounding. And where do you live?

Manchester! Isn't Manchester Just west of the Pennines? Uncanny. Beyond belief. Ketchup, you say? Don't clear it up, we'll get a camera crew out there straight away. Tell me, Richard, when did you first notice your strange mystic power?'

The audience for a prime-time television show in the north of England must be well over a million. Given a million households for an hour, you can be confident that somebody out there will throw up. At a pinch, somebody who just felt poorly would probably earn a round of applause.

But will the presenter point all this out? He will not. Will he call attention to the millions of households in which nothing untoward happened, who did not phone in? Of course not. That would spoil the fun and be bad for the ratings - whose side are you on?

My example was hypothetical, but something very similar regularly happens in the current epidemic of "paranormal" programmes on television. Here is an actual item from CarIton's Beyond Belief, produced and presented by David Frost: a father and son team in which the son, blindfolded, can see -through his father's eyes", Sir David personally checks the blindfold to reassure us there is no cheating. A young woman sashays in to perform her brief cameo task of spinning a roulette wheel. The ball stops in slot number 13. The father stares fixedlat it, clenching and unclenching his fists under the strain, and asks his ,blindfolded son in a strangled shout whether he can do it. -Yes, 1 think so," croaks the son. -Thirteen.Wild applause. How astonishing! And don't forget, viewers, this is all live TV, and factual programming, not fiction like the BBC's The X Flies. Astounding!

What we have just experienced is indistinguishable from a familiar, rather mediocre conjuring trick. The only difference is that a television company has seen fit to bill it as "paranormal". The basic formula for these shows is simple but effective. Wheel in a succession of performers, but repeatedly tell the audience they are not conjurers but genuinely supernatural. Yet these acts seem to be subjected to less control than a performing magician would be. 1 imagine the telepathy stunt depends upon some kind of coded message passing from father to son . There are numerous ways in which such messages could be sent. Any decent conjuror goes into an elaborate, sleeve-emptying pantomime to rule out the more obvious tricks. Perhaps place father and son in sealed, separate rooms. Perhaps search shoes for hidden radio transmitters.

In the present case, no such technology is necessary. The father always asks his son, out loud, "Can you do it?." or an equivalent question. Any conjurer knows there are many ways in which a two-digit number could be coded in the details of such a message. Information could lie in the exact words used, in the durations of pauses, in the pitch or loudness of the voice, perhaps interspersed with throat-clearings or foot-tappings. In this case, I distinctly heard a throaty whisper at the crucial moment. Yes, yes, it was probably just a cameraman whispering to the tea-maker. But if the show was sufficiently unrigorous to permit audible whispering, it was certainly unrigorous enough to permit less obvious means of communication.

In another programme, a performer demonstrated his magnetic personality by "willing" objects to slide around a table. Any conjuror would have allowed the audience a ritual peep under the table to check for hidden magnets. In this case, neither the viewers nor studio audience were granted even this courtesy.

The whole point of a good conjuror is that we, the audience, do not know how he does it. But a good conjuror never claims to have done anything more than a trick and, however mystified we may remain, we do not take it as evidence for telepathy, paranormal psychic powers or energy fields unknown to physics. Several good conjurors, from the great Canadian James Randi down, have made it their business to replicate all the tricks of the television paranormalists. If the producers of these television programmes were genuinely interested in investigating the truth, the least they could do would be to invite Randi, or another sceptical conjuror, into the studio to duplicate, publicly, the tricks.

This does occasionally happen, but not often enough to dent the gullibility of the studio audience. On CarIton's The Paranoirnal World of Paul McKenna, one performer came on, did a brief but good trick and then clearly stated that a trick was all it was. The audience applauded politely. But did they go on to question the paranormal claims of the other performers? Did the compere? Alas. no. Okay, so that one was a trick. But surely this next one is genuine? Indeed, the honesty with which an occasional trick is admitted may serve to reinforce confidence in paranormal claims.

The BBC is falling over itself to put on drivel similar to CarIton's. In one episode of BBC2's Secrets of the Paranormal., a builder turned "healer" is given the prestige of the channel to tell us that his body is inhabited by a doctor called Paul of Judaea, dead 2,000 years. Some sad people think they are Napoleon reincarnated, but we do not expect them to be granted a prime-time "factual" television slot to air their delusions. Who in the BBC is responsible for commissioning this and why aren't they fired?

The defence offered is that viewers should be free to make up their own minds. Wouldn't it be undesirable censorship to "suppress" such programmes? Oh, please! As others have pointed out, you should on the same grounds grant prime tline to the Flat Earth Society. Producers, editors and controllers, at least where factual programming is concerned, have a responsibility to exercise some control.

Or, it may be said, aren't scientists being arrogant in claiming to have explained everything? Isn't it healthy to have alternative hypotheses laid before us? Yes, of course it is. Scientists certainly do not have an adequate explanation for everything. But "paranormal" claims must be treated with the same rigorous scepticism as scientific hypotheses are. On a recent episode of BBC 1's Out of this World, presented by Carol Vorderman (shamelessly abusing her Tomcarow's World "scientific"credentials), "Mystic Carol" spent a night alone with a camcorder in a haunted hotel. Unfortunately she did not see a ghost, but she did feel pretty spoky in one room that was abnormally cold. Oooh!

Yet scientists are required to back up their claims not with private feelings but with publicly checkable evidence. Their experiments must have rigorous controls to eliminate spurious effects. And statistical analysis eliminates the suspicion (or at least measures the likelihood) that the apparent effect might have happened by chance alone.

Paranormal phenomena have a habit of going away whenever they are tested under rigorous conditions. This is why the $740,000 reward of James Randi, offered to anyone who can demonstrate a paranormal effect under proper scientific controls, is safe. Why don't the television editors insist on.some equivalently rigorous test? Could it be that they believe the alleged paranormal powers would evaporate and bang go the ratings?

Consider this. If a paranormalist could really give an unequivocal demonstration of telepathy (precognition, psychokinesis, reincarnation, whatever it is), he would be the discoverer of a totally new principle unknown to physical science. The discoverer of the new energy field that links mind to mind in telepathy. or of the new fundamental force that moves objects around a table top, deserves a Nobel prize and would probably get one. If you are in possession of this revolutionary secret of science, why not prove it and be hailed as the new Newton? Of course, we know the answer. You can't do it. You are a fake.

Yet the final indictment against the television decision-makers is more profound and more serious. Their recent splurge of paranormalism debauches true science and undermines the efforts of their own excellent science departments. The universe is a strange and wondrous place. The truth is quite odd enough to need no help from pseudoscientific charlatans. The public appetite for wonder can be fed, through the powerful medium of television, without compromising the principles of honesty and reason.

Today we are faced with a real possibility that fossil life is embedded in ancient Mars rock. Will a public gorged on a pseudoscientific pap of alien abduction lore, lulled into possession of a spastic critical faculty, be capable of recognising what a fantastically exciting possibility Martian life. if verified, would be, how far-reaching and revolutionary its consequences for our world view? Or has television once too often cried wolf?

Richard Dawkins is Charles Simonyi Professor of the Public Understanding of Science at Oxford University and the author of Climbing Mount Improbable. He will debate Selling Out to the Supernatural at the Edinburgh Television Festival tomorrow.

Is Science a Religion?

by Richard Dawkins
The 1996 Humanist of the Year asked this question in a speech accepting the honor from the American Humanist Association.
This article is adapted from his speech in acceptance of the 1996 Humanist of the Year Award from the American Humanist Association.

It is fashionable to wax apocalyptic about the threat to humanity posed by the AIDS virus, "mad cow" disease, and many others, but I think a case can be made that faith is one of the world's great evils, comparable to the smallpox virus but harder to eradicate.

Faith, being belief that isn't based on evidence, is the principal vice of any religion. And who, looking at Northern Ireland or the Middle East, can be confident that the brain virus of faith is not exceedingly dangerous? One of the stories told to the young Muslim suicide bombers is that martyrdom is the quickest way to heaven -- and not just heaven but a special part of heaven where they will receive their special reward of 72 virgin brides. It occurs to me that our best hope may be to provide a kind of "spiritual arms control": send in specially trained theologians to deescalate the going rate in virgins.

Given the dangers of faith -- and considering the accomplishments of reason and observation in the activity called science -- I find it ironic that, whenever I lecture publicly, there always seems to be someone who comes forward and says, "Of course, your science is just a religion like ours. Fundamentally, science just comes down to faith, doesn't it?"

Well, science is not religion and it doesn't just come down to faith. Although it has many of religion's virtues, it has none of its vices. Science is based upon verifiable evidence. Religious faith not only lacks evidence, its independence from evidence is its pride and joy, shouted from the rooftops. Why else would Christians wax critical of doubting Thomas? The other apostles are held up to us as exemplars of virtue because faith was enough for them. Doubting Thomas, on the other hand, required evidence. Perhaps he should be the patron saint of scientists.

One reason I receive the comment about science being a religion is because I believe in the fact of evolution. I even believe in it with passionate conviction. To some, this may superficially look like faith. But the evidence that makes me believe in evolution is not only overwhelmingly strong; it is freely available to anyone who takes the trouble to read up on it. Anyone can study the same evidence that I have and presumably come to the same conclusion. But if you have a belief that is based solely on faith, I can't examine your reasons. You can retreat behind the private wall of faith where I can't reach you.

Now in practice, of course, individual scientists do sometimes slip back into the vice of faith, and a few may believe so single-mindedly in a favorite theory that they occasionally falsify evidence. However, the fact that this sometimes happens doesn't alter the principle that, when they do so, they do it with shame and not with pride. The method of science is so designed that it usually finds them out in the end.

Science is actually one of the most moral, one of the most honest disciplines around -- because science would completely collapse if it weren't for a scrupulous adherence to honesty in the reporting of evidence. (As James Randi has pointed out, this is one reason why scientists are so often fooled by paranormal tricksters and why the debunking role is better played by professional conjurors; scientists just don't anticipate deliberate dishonesty as well.) There are other professions (no need to mention lawyers specifically) in which falsifying evidence or at least twisting it is precisely what people are paid for and get brownie points for doing.

Science, then, is free of the main vice of religion, which is faith. But, as I pointed out, science does have some of religion's virtues. Religion may aspire to provide its followers with various benefits -- among them explanation, consolation, and uplift. Science, too, has something to offer in these areas.

Humans have a great hunger for explanation. It may be one of the main reasons why humanity so universally has religion, since religions do aspire to provide explanations. We come to our individual consciousness in a mysterious universe and long to understand it. Most religions offer a cosmology and a biology, a theory of life, a theory of origins, and reasons for existence. In doing so, they demonstrate that religion is, in a sense, science; it's just bad science. Don't fall for the argument that religion and science operate on separate dimensions and are concerned with quite separate sorts of questions. Religions have historically always attempted to answer the questions that properly belong to science. Thus religions should not be allowed now to retreat away from the ground upon which they have traditionally attempted to fight. They do offer both a cosmology and a biology; however, in both cases it is false.

Consolation is harder for science to provide. Unlike religion, science cannot offer the bereaved a glorious reunion with their loved ones in the hereafter. Those wronged on this earth cannot, on a scientific view, anticipate a sweet comeuppance for their tormentors in a life to come. It could be argued that, if the idea of an afterlife is an illusion (as I believe it is), the consolation it offers is hollow. But that's not necessarily so; a false belief can be just as comforting as a true one, provided the believer never discovers its falsity. But if consolation comes that cheap, science can weigh in with other cheap palliatives, such as pain-killing drugs, whose comfort may or may not be illusory, but they do work.

Uplift, however, is where science really comes into its own. All the great religions have a place for awe, for ecstatic transport at the wonder and beauty of creation. And it's exactly this feeling of spine-shivering, breath-catching awe -- almost worship -- this flooding of the chest with ecstatic wonder, that modern science can provide. And it does so beyond the wildest dreams of saints and mystics. The fact that the supernatural has no place in our explanations, in our understanding of so much about the universe and life, doesn't diminish the awe. Quite the contrary. The merest glance through a microscope at the brain of an ant or through a telescope at a long-ago galaxy of a billion worlds is enough to render poky and parochial the very psalms of praise.

Now, as I say, when it is put to me that science or some particular part of science, like evolutionary theory, is just a religion like any other, I usually deny it with indignation. But I've begun to wonder whether perhaps that's the wrong tactic. Perhaps the right tactic is to accept the charge gratefully and demand equal time for science in religious education classes. And the more I think about it, the more I realize that an excellent case could be made for this. So I want to talk a little bit about religious education and the place that science might play in it.

I do feel very strongly about the way children are brought up. I'm not entirely familiar with the way things are in the United States, and what I say may have more relevance to the United Kingdom, where there is state-obliged, legally-enforced religious instruction for all children. That's unconstitutional in the United States, but I presume that children are nevertheless given religious instruction in whatever particular religion their parents deem suitable.

Which brings me to my point about mental child abuse. In a 1995 issue of the Independent, one of London's leading newspapers, there was a photograph of a rather sweet andtouching scene. It was Christmas time, and the picture showed three children dressed up as the three wise men for a nativity play. The accompanying story described one child as a Muslim, one as a Hindu, and one as a Christian. The supposedly sweet and touching point of the story was that they were all taking part in this Nativity play.

What is not sweet and touching is that these children were all four years old. How can you possibly describe a child of four as a Muslim or a Christian or a Hindu or a Jew? Would you talk about a four-year-old economic monetarist? Would you talk about a four-year-old neo-isolationist or a four-year-old liberal Republican? There are opinions about the cosmos and the world that children, once grown, will presumably be in a position to evaluate for themselves. Religion is the one field in our culture about which it is absolutely accepted, without question -- without even noticing how bizarre it is -- that parents have a total and absolute say in what their children are going to be, how their children are going to be raised, what opinions their children are going to have about the cosmos, about life, about existence. Do you see what I mean about mental child abuse?

Looking now at the various things that religious education might be expected to accomplish, one of its aims could be to encourage children to reflect upon the deep questions of existence, to invite them to rise above the humdrum preoccupations of ordinary life and think sub specie aeternitatis.

Science can offer a vision of life and the universe which, as I've already remarked, for humbling poetic inspiration far outclasses any of the mutually contradictory faiths and disappointingly recent traditions of the world's religions.

For example, how could children in religious education classes fail to be inspired if we could get across to them some inkling of the age of the universe? Suppose that, at the moment of Christ's death, the news of it had started traveling at the maximum possible speed around the universe outwards from the earth. How far would the terrible tidings have traveled by now? Following the theory of special relativity, the answer is that the news could not, under any circumstances whatever, have reached more that one-fiftieth of the way across one galaxy -- not one- thousandth of the way to our nearest neighboring galaxy in the 100-million-galaxy-strong universe. The universe at large couldn't possibly be anything other than indifferent to Christ, his birth, his passion, and his death. Even such momentous news as the origin of life on Earth could have traveled only across our little local cluster of galaxies. Yet so ancient was that event on our earthly time-scale that, if you span its age with your open arms, the whole of human history, the whole of human culture, would fall in the dust from your fingertip at a single stroke of a nail file.

The argument from design, an important part of the history of religion, wouldn't be ignored in my religious education classes, needless to say. The children would look at the spellbinding wonders of the living kingdoms and would consider Darwinism alongside the creationist alternatives and make up their own minds. I think the children would have no difficulty in making up their minds the right way if presented with the evidence. What worries me is not the question of equal time but that, as far as I can see, children in the United Kingdom and the United States are essentially given no time with evolution yet are taught creationism (whether at school, in church, or at home).

It would also be interesting to teach more than one theory of creation. The dominant one in this culture happens to be the Jewish creation myth, which is taken over from the Babylonian creation myth. There are, of course, lots and lots of others, and perhaps they should all be given equal time (except that wouldn't leave much time for studying anything else). I understand that there are Hindus who believe that the world was created in a cosmic butter churn and Nigerian peoples who believe that the world was created by God from the excrement of ants. Surely these stories have as much right to equal time as the Judeo-Christian myth of Adam and Eve.

So much for Genesis; now let's move on to the prophets. Halley's Comet will return without fail in the year 2062. Biblical or Delphic prophecies don't begin to aspire to such accuracy; astrologers and Nostradamians dare not commit themselves to factual prognostications but, rather, disguise their charlatanry in a smokescreen of vagueness. When comets have appeared in the past, they've often been taken as portents of disaster. Astrology has played an important part in various religious traditions, including Hinduism. The three wise men I mentioned earlier were said to have been led to the cradle of Jesus by a star. We might ask the children by what physical route do they imagine the alleged stellar influence on human affairs could travel.

Incidentally, there was a shocking program on the BBC radio around Christmas 1995 featuring an astronomer, a bishop, and a journalist who were sent off on an assignment to retrace the steps of the three wise men. Well, you could understand the participation of the bishop and the journalist (who happened to be a religious writer), but the astronomer was a supposedly respectable astronomy writer, and yet she went along with this! All along the route, she talked about the portents of when Saturn and Jupiter were in the ascendant up Uranus or whatever it was. She doesn't actually believe in astrology, but one of the problems is that our culture has been taught to become tolerant of it, vaguely amused by it -- so much so that even scientific people who don't believe in astrology sort of think it's a bit of harmless fun. I take astrology very seriously indeed: I think it's deeply pernicious because it undermines rationality, and I should like to see campaigns against it.

When the religious education class turns to ethics, I don't think science actually has a lot to say, and I would replace it with rational moral philosophy. Do the children think there are absolute standards of right and wrong? And if so, where do they come from? Can you make up good working principles of right and wrong, like "do as you would be done by" and "the greatest good for the greatest number" (whatever that is supposed to mean)? It's a rewarding question, whatever your personal morality, to ask as an evolutionist where morals come from; by what route has the human brain gained its tendency to have ethics and morals, a feeling of right and wrong?

Should we value human life above all other life? Is there a rigid wall to be built around the species Homo sapiens, or should we talk about whether there are other species which are entitled to our humanistic sympathies? Should we, for example, follow the right-to-life lobby, which is wholly preoccupied with human life, and value the life of a human fetus with the faculties of a worm over the life of a thinking and feeling chimpanzee? What is the basis of this fence that we erect around Homo sapiens -- even around a small piece of fetal tissue? (Not a very sound evolutionary idea when you think about it.) When, in our evolutionary descent from our common ancestor with chimpanzees, did the fence suddenly rear itself up?

Well, moving on, then, from morals to last things, to eschatology, we know from the second law of thermodynamics that all complexity, all life, all laughter, all sorrow, is hell bent on leveling itself out into cold nothingness in the end. They -- and we -- can never be more then temporary, local buckings of the great universal slide into the abyss of uniformity.

We know that the universe is expanding and will probably expand forever, although it's possible it may contract again. We know that, whatever happens to the universe, the sun will engulf the earth in about 60 million centuries from now.

Time itself began at a certain moment, and time may end at a certain moment -- or it may not. Time may come locally to an end in miniature crunches called black holes. The laws of the universe seem to be true all over the universe. Why is this? Might the laws change in these crunches? To be really speculative, time could begin again with new laws of physics, new physical constants. And it has even been suggested that there could be many universes, each one isolated so completely that, for it, the others don't exist. Then again, there might be a Darwinian selection among universes.

So science could give a good account of itself in religious education. But it wouldn't be enough. I believe that some familiarity with the King James version of the Bible is important for anyone wanting to understand the allusions that appear in English literature. Together with the Book of Common Prayer, the Bible gets 58 pages in the Oxford Dictionary of Quotations. Only Shakespeare has more. I do think that not having any kind of biblical education is unfortunate if children want to read English literature and understand the provenance of phrases like "through a glass darkly," "all flesh is as grass," "the race is not to the swift," "crying in the wilderness," "reaping the whirlwind," "amid the alien corn," "Eyeless in Gaza," "Job's comforters," and "the widow's mite."

I want to return now to the charge that science is just a faith. The more extreme version of that charge -- and one that I often encounter as both a scientist and a rationalist -- is an accusation of zealotry and bigotry in scientists themselves as great as that found in religious people. Sometimes there may be a little bit of justice in this accusation; but as zealous bigots, we scientists are mere amateurs at the game. We're content to argue with those who disagree with us. We don't kill them.

But I would want to deny even the lesser charge of purely verbal zealotry. There is a very, very important difference between feeling strongly, even passionately, about something because we have thought about and examined the evidence for it on the one hand, and feeling strongly about something because it has been internally revealed to us, or internally revealed to somebody else in history and subsequently hallowed by tradition. There's all the difference in the world between a belief that one is prepared to defend by quoting evidence and logic and a belief that is supported by nothing more than tradition, authority, or revelation.

Richard Dawkins is Charles Simonyi Professor of the Public Understanding of Science at Oxford University. His books include The Selfish Gene, The Blind Watchmaker, River Out of Eden, and, most recently, Climbing Mount Improbable. This article is adapted from his speech in acceptance of the 1996 Humanist of the Year Award from the American Humanist Association.

EDGE 53 — April 8, 1999

Richard Dawkins Steven Pinker

THE THIRD CULTURE

IS SCIENCE KILLING THE SOUL?
Richard Dawkins & Steven Pinker
Chaired by Tim Radford

THE REALITY CLUB

Jaron Lanier on Daniel C. Dennett's "The Evolution of Culture"

EDGE IN THE NEWS

MIND MELD
By Tom Samiljan
Time Out New York
April 8-15, 1999 Issue No. 185

[15,780 words]

IS SCIENCE KILLING THE SOUL?
Richard Dawkins & Steven Pinker

Chaired by Tim Radford

Introduction by
John Brockman

On February 10, 1999, The Guardian-Dillons Debate at the Westminster Central Hall in London featured Richard Dawkins and Steven Pinker in an event chaired by Tim Radford, Science Editor of *The Guardian*. Sold out weeks in advance, the evening attracted 2,300 attendees, with hundreds waiting outside. It was one of the toughest tickets in London in years.

The evening echoes an event held in Munich last November, "The Digital Planet", for which a thousand people turned out in a driving rainstorm to see and hear Dawkins and Pinker as well as Daniel C. Dennett and Jared Diamond introduced by Douglas Adams. More than a hundred journalists were in the audience. The lobby of the hotel looked more like the press center for a presidential election campaign.

Clearly, something is happening with this group of intellectuals.

While *The Guardian*-Dillons series is characterized as a "debate", Dawkins and Pinker, who are in general agreement across broad areas, presented what I would characterize as a "a high level seminar." As Dawkins pointed out: "The adversarial approach to truth isn't necessarily always the best one. On the contrary, when two people disagree strongly, a great deal of time may be wasted. It's been well said that when two opposite points of view are advocated with equal vigor, the truth does not necessarily lie mid-way between them. And in the same way, when two people agree about something, it's just possible that the reason they agree is that they're both right. There's also I suppose the hope that in a dialogue of this sort each speaker may manage to achieve a joint understanding with the other one, better than he would have done on his own."

-JB

RICHARD DAWKINS is an evolutionary biologist and the Charles Simonyi Professor For The Understanding Of Science at Oxford University; Fellow of New College; author of *The Selfish Gene* (1976), 2d ed. 1989), *The Extended Phenotype* (1982), *The Blind Watchmaker* (1986), *River out of Eden* (1995) (*ScienceMasters Series*), *Climbing Mount Improbable* (1996), and *Unweaving the Rainbow* (1998).

(Click here for Dawkins on *Edge*)

STEVEN PINKER is professor in the Department of Brain and Cognitive Sciences at MIT; director of the McDonnell-Pew Center for Cognitive Neuroscience at MIT; author of *Language Learnability and Language Development* (1984), *Learnability and Cognition* (1989), *The Language Instinct* (1994), and *How the Mind Works* (1997).

(Click here for Pinker on *Edge*)

TIM RADFORD is Science Editor of *The Guardian*

Edge thanks *The Guardian* and Dillons for permission to run the Guardian-Dillons Debate at the Westminster Central Hall on February 10, 1999

Richard Dawkins & *Steven Pinker*

Is Science Killing The Soul?

Chaired by Tim Radford

TIM RADFORD: My name is Tim Radford; I'm the science editor of *The Guardian*. And I'm here to do a very strange thing, I'm here to introduce two people who obviously need no introduction whatsoever, otherwise you wouldn't be here. There are I gather 2,300 of you, and there are another three or four hundred weeping and gnashing their teeth outside. So you knew why you were coming. You thought you knew what you were going to hear. What you are going to hear is from two great story tellers of modern science. Science is a story, we're story-telling animals, we tell each other stories to explain why we're here, and since we don't know the outcome of our narrative, we conduct these things in the form of a story-so-far. This is what science does for us, but of course we've always done that. live later.

There are three great stories in science. One of them is where the universe came from. One of them is where life came from. And the third is where we came from. Now this last aspect breaks into several different aspects, really. One is: who is this person called a human -- or indeed who is this person called a person? Where did he come from, or she? Why are we here? What are we doing, where are we going? And how did we get here, and why did one particular group of creatures on the plains of Africa suddenly pick up a stone and start playing with it, scratching things, or skinning things, doing things, going places, colonizing the globe. The second question is not about the entity called human, but the identity within that entity. What is this mind for? Why is it so big? Why could it encompass absolutely anything? Why does any mind seem to be able to encompass absolutely everything? It's all we've got, but we're not that conscious of it. We think we're occupying reality, but of course it's only our brain that tells us this. We have people here who can explain this much better than I can.

What's going on? Well, we have reached a curious situation in science in which it's possible for people to propose that science might be able to provide all the answers. Neither of the two guests tonight actually make these claims, but there are scientists who do claim such things. And one of the pieces of machinery that they use is sometimes known as Darwinism, or the theory of evolution, or just the action of natural selection upon random mutation. It doesn't really matter, because we're just going to call it tonight, Darwinism. At least I am. Professor Dawkins will actually have a better explanation if you ask him.

Is it important to us? Yes it is important. Natural selection is the environment. We started altering our environment back at the beginning of the 19th century. We have now comprehensively changed it, so we run the world for our benefit, and every now and then it gets a bit fragile at the edges, we have to start worrying about the ozone layer, or the carbon dioxide crisis -- but we have changed the environment. More alarmingly, we have begun to understand how we could change ourselves; we could take charge of our own genes. We aren't doing it yet. You hear talk about designer babies; there are no such things, but we have reached the stage where we have to ask ourselves whether we want some of our babies. We can now see what kind of baby we might be about to have, and people are suddenly thrust into the position of having to ask themselves, what is a gene, what does it do, and how will it all turn out? So these are very important questions, and they do actually concern us. These questions are not academic.

Nor are they new. There's a wonderful passage in the Book of Job, Chapter 38, I think, in which the poet who composed Job speaks as if God, and asks Job a series of questions which begin, Hath the rain a Father? Who hath begot the drops of dew? out of whose womb came the ice? and the hoary frost of Heaven, who hath engendered it? the waters are hid as with stone, and the face of the deep is frozen. Canst thou bind the sweet influence of Pleiades, or loose the bands of Orion?? Now that of course is great poetry, and one of the issues that we are discussing here is whether science is killing the soul in the sense of poetry. All I point out to you is that that is a series of questions about the hydrological cycle, you cannot say that it's just poetry, they are also real questions which demand real answers, which people are supplying, scientists among them.

We have with us tonight two extraordinarily gifted writers. One of them is Richard Dawkins, Charles Simonyi Professor of Public Understanding of Science at the University of Oxford, and he's the man who more than two decades ago introduced the notion of the selfish gene, upsetting a lot of people, creating a debate that hasn't stopped yet. He followed this up with a series of dazzling books, of which the latest is called *Unweaving the Rainbow*, which is not just about

Darwinism, but about science itself, and about our understanding of the planet we live on. The other is Steven Pinker, who is a professor of psychology at the Massachusetts Institute of Technology. And he leapt onto the best-seller list about three years ago with a wonderful book called *The Language Instinct*, which was just about this remarkable ability that 3-year-olds have to learn any grammar that happens to be lying around, with the implication that either babies are born knowing, in principle, all the languages that have ever been invented, or yet to be invented, -- or that there is a universal grammar and it's already composed in their own brains. If so, what a remarkable thing the brain is. I'll let them talk about that. The subject tonight is "Is Science Killing the Soul?" You will not find this a straight-forward head-to-head debate in which one man says yes and the other says no. It all depends, as Professor Joad used to say, on what you mean by soul. Richard Dawkins.

RICHARD DAWKINS: Thank you very much, Tim. But the word debate does appear up on the notice there. It may turn into more of a dialogue than a debate. I suspect that Steve Pinker and I are perhaps largely of the same mind here, so there's a risk that anybody who's come here expecting a confrontation will go away disappointed by too much agreement. I don't know if this will happen, but if it does, I don't think there's any need to apologize. The adversarial approach to truth isn't necessarily always the best one. On the contrary, when two people disagree strongly, a great deal of time may be wasted. It's been well said that when two opposite points of view are advocated with equal vigor, the truth does not necessarily lie mid-way between them. And in the same way, when two people agree about something, it's just possible that the reason they agree is that they're both right. There's also I suppose the hope that in a dialogue of this sort each speaker may manage to achieve a joint understanding with the other one, better than he would have done on his own.

Is science killing the soul? This is a cunning title, because it cunningly mixes two different meanings of soul. The first and oldest meaning of soul, which I'm going to call Soul One, takes off from one set of definitions. I'm going to quote several related definitions from the Oxford dictionary:

"The principle of life in man or animals -- animate existence."

"The principle of thought and action in man commonly regarded as an entity distinct from the body, the spiritual part of man in contrast to the purely physical."

"The spiritual part of man regarded as surviving after death, and as susceptible of happiness or misery in a future state."

"The disembodied spirit of a deceased person regarded as a separate entity and as invested with some amount of form and personality."

So Soul One refers to a particular theory of life. It's the theory that there is something non-material about life, some non-physical vital principle. It's the theory according to which a body has to be animated by some anima. Vitalized by a vital force. Energized by some mysterious energy. Spiritualized by some mysterious spirit. Made conscious by some mysterious thing or substance called consciousness. You'll notice that all those definitions of Soul One are circular and non-productive. It's no accident. Julian Huxley once satirically likened vitalism to the theory that a railway engine works by "force-locomotif." I don't always agree with Julian Huxley, but here he hit the nail beautifully. In the sense of Soul One, science has either killed the soul or is in the process of doing so.

But there is a second sense of soul, Soul Two, which takes off from another one of the Oxford dictionary's definitions:

"Intellectual or spiritual power. High development of the mental faculties. Also, in somewhat weakened sense, deep feeling, sensitivity."

In this sense, our question tonight means, Is science killing soulfulness? Is it killing esthetic sensitivity, artistic sensibility, creativity? The answer to this question, Is science killing Soul Two?, is a resounding No. The very opposite is the case. But it is a question worth pursuing, because there have been many people, from genuinely great poets all the way down to Brian Appleyard and Fay Weldon, who've given a strong Yes answer to the question, Is science killing the soul? It's Soul Two that Keats and Lamb meant when they thought that Newton had destroyed all the poetry of the rainbow when he unwove it.

"Do not all charms fly
At the mere touch of cold philosophy?
There was an awful rainbow once in heaven;
We know her texture; she is given
In the dull catalogue of common things,
Philosophy will clip an Angel's wings,
Conquer all mysteries by rule and line,
Empty the haunted air, and gnomed mine‹
Unweave a rainbow . . ."

Well, I've written a book which is one long reply to that particular kind of anti-scientific attitude. In the sense of Soul Two, science doesn't kill the soul, it gives the soul constant and exhilarating re-birth.

Turning back to Soul One -- in the first chapter of Steve Pinker's book *How the Mind Works* he says, "I want to convince you that our minds are not animated by some godly vapor or single wonder-principle. The mind, like the Apollo spacecraft, is designed to solve many engineering problems, and thus is packed with high-tech systems, each contrived to overcome its own obstacles." In the same paragraph, he moves on to Soul Two when he says, " . . . I believe that the discovery by cognitive science and artificial intelligence of the technical challenges overcome by our mundane mental activity is one of the great revelations of science, an awakening of the imagination comparable to learning that the universe is made up of billions of galaxies or that a drop of pond water teems with microscopic life." Well, awakening of the imagination is a pretty good definition of Soul Two. And in that sense, far from killing the soul, science may prove to be its greatest awakener.

Carl Sagan wrote, shortly before he died,

"How is it that hardly any major religion has looked at science and concluded, 'This is better than we thought! The Universe is much bigger than our prophets said, grander, more subtle, more elegant'? Instead they say, 'No, no, no! My god is a little god, and I want him to stay that way.' A religion, old or new, that stressed the magnificence of the Universe as revealed by modern science might be able to draw forth reserves of reverence and awe hardly tapped by the conventional faiths."

Well it's common enough for people to agree that religions have got the facts all wrong, but "Nevertheless," they go on to say, "you have to admit that religions do provide something that people need. We crave a deeper meaning to life, a deeper, more imaginative understanding of the mystery of existence." Well, in the passage I've just quoted, Sagan seems to be criticizing religions not just for getting it wrong, which many people would accept, but for their deficiencies precisely in the sphere in which they are supposed to retain some residual virtue. Religions are *not* imaginative, not poetic, not soulful. On the contrary, they are parochial, small-minded, niggardly with the human imagination, precisely where science is generous.

Now, there are, of course many unsolved problems, and scientists are the first to admit this. There are aspects of human subjective consciousness that are deeply mysterious. Neither Steve Pinker nor I can explain human subjective consciousness -- what philosophers call qualia. In *How the Mind Works* Steve elegantly sets out the problem of subjective consciousness, and asks where it comes from and what's the explanation. Then he's honest enough to say, "Beats the heck out of me." That is an honest thing to say, and I echo it. We don't know. We don't understand it.

There's a cheap debating trick which implies that if, say, science can't explain something, this must mean that some other discipline can. If scientists suspect that all aspects of the mind have a scientific explanation but they can't actually say what that explanation is yet, then of course it's open to you to doubt whether the explanation ever will be forthcoming. That's a perfectly reasonable doubt. But it's *not* legitimately open to you to substitute a word like soul, or spirit, as if that constituted an explanation. It is not an explanation, it's an evasion. It's just a name for that which we don't understand. The scientist may agree to use the word soul for that which we don't understand, but the scientist adds, "But we're working on it, and one day we hope we shall explain it." The dishonest trick is to use a word like soul or spirit as if it constituted an explanation.

Consciousness is still mysterious. And scientists, I think, all admit it. But we ought to remember that it's not that long ago that life itself was thought to be equally mysterious. I'm going to quote from a book, *A Short History of Biology* by Charles Singer, a reputable historian of science, published in 1931, where he says, about the gene,

". . . despite interpretations to the contrary, the theory of the gene is not a 'mechanist' theory. The gene is no more comprehensible as a chemical or physical entity than is the cell or, for that matter, the organism itself. . . . If I ask for a living chromosome, that is, for the only effective kind of chromosome, no one can give it to me except in its living surroundings any more than he can give me a living arm or leg. The doctrine of the relativity of functions is as true for the gene as it is for any of the organs of the body. They exist and function only in relation to other organs. Thus the last of the biological theories leaves us where the first started, in the presence of a power called life or psyche which is not only of its own kind but unique in each and all of its exhibitions."

That was 1931. In 1953, Watson and Crick drove a coach and horses through it, blew it out of the water. Genes are isolatable, they can be taken out of bodies, they can be sequenced, they can be put in bottles, they can be written out in a book and stored away in a library, and then at any time in the future they can be simply typed back into a machine and the original gene reconstituted. It could be put back into a living creature where it will work exactly the way it originally did. In the context of the gene, the understanding, the explanation is more or less total. And it was completely unexpected only a few decades ago.

My suspicion, my hunch, my hope, is that the same thing is going to be done for the conscious mind. Probably within the next century. Soul One will finally be killed, and good riddance. But in the process, Soul Two, far from being destroyed, will still be finding new worlds to conquer.

I'm going to end my prepared remarks by saying a little bit about Darwinism, because Darwinism is something which obviously Steve Pinker and I have in common in our approach to science. This, I think, may be the one place where possibly some slight disagreement may emerge. For me, Darwinism is not actually, surprisingly enough, the theory of the selfish gene. It's the theory of the selfish replicator. Darwinism is a much more general idea than the particular version of Darwinism which happens to explain life on this planet. Darwinism in this more general universal sense refers to the differential survival of any kind of self-replicating coded information which has some sort of power or influence over its probability of being replicated. DNA is the main kind of replicating entity that we know on this planet that has that property. When we look at living things on this planet, overwhelmingly the kind of explanation we should be seeking, if we ask what the functional significance is an explanation in terms of the good of the genes. Any adaptation is for the good of the genes which made that adaptation.

STEVEN PINKER: I'm going to discuss an idea that elicits wildly opposite reactions. Some people find it a shocking claim with radical implications for morals and every value that we hold dear. Other people think that it's a claim that was established a hundred years ago, that the excitement is only in how we work out the details, and that it has few if any implications for our values and ethics. That is the idea that the mind is the physiological activity of the brain, in particular the information processing activity of the brain; that the brain, like other organs, is shaped by the genes; and that in turn, the genome was shaped by natural selection and other evolutionary processes. I am among those who think that this should no longer be a shocking claim, and that the excitement is in fleshing out the details, and showing exactly how our perception, decision-making, and emotions can be tied to the activity of the brain.

Three new sciences are now vividly rooting our mental processes in our biology. Cognitive neuroscience, the attempt to relate thought, perception and emotion to the functioning of the brain, has pretty much killed Soul One, in Richard's sense. It should now be clear to any scientifically literate person that we don't have any need for a ghost in the machine, as Gilbert Ryle memorably put it. Many kinds of evidence show that the mind is an entity in the physical world, part of a causal chain of physical events. If you send an electric current through the brain, you cause the person to have a vivid experience. If a part of the brain dies because of a blood clot or a burst artery or a bullet wound, a part of the person is gone -- the person may lose an ability to see, think, or feel in a certain way, and the entire personality may change. The same thing happens gradually when the brain accumulates a protein called beta-amyloid in the tragic disease known as Alzheimer's. The person -- the soul, if you want -- gradually disappears as the brain decays from this physical process.

We know that every form of mental activity -- every emotion, every thought, every percept -- gives off electrical, magnetic, or metabolic signals that can be recorded with increasing precision by Positron Emission Tomography, functional Magnetic Resonance Imaging, Magnetoencephalography, and other techniques. We know that if you take a knife and section the corpus callosum (which joins the two cerebral hemispheres) you have the equivalent of two minds -- perhaps even two souls -- in the same skull. We know that if you look at the brain under a microscope it has a breathtaking degree of complexity -- on the order of a trillion synapses -- that's fully commensurate with the breathtaking complexity of human thought and experience. We know that when the brain dies, the person goes out of existence. I consider it to be a significant empirical discovery that one cannot communicate with the dead, and excellent evidence that Soul One, in Richard's sense, does not exist.

A second science, behavioral genetics, has shown that there is a fascinating degree of specificity in our genome. You've all heard of the remarkable studies of monozygotic twins reared apart, who are remarkably similar in intelligence, personality, and attitudes -- even in their opinion on the death penalty and their tastes in music and clothing. And just in the past year there have been discoveries of genetic markers, and in some case genes and even gene products, associated with mental traits such as intelligence, spatial cognition, control of speech, the desire to seek sensation, and the tendency to be overly anxious.

The third science that's connecting mind to biology is evolutionary psychology, which takes an approach to understanding the mind that has long been fruitful in understanding the organs of the body. We can't make sense of an organ like the eye without considering it to have a function, or a purpose - not in a mystical, teleological sense, but in the sense of an illusion of engineering. That illusion, we now know, is a consequence of Darwin's process of natural selection. Everyone agrees that the eye is a remarkable bit of natural "engineering," and that may now be explained as a product of natural selection rather than as the handiwork of a cosmic eye-designer or as a massive coincidence in tissue formation. But the eye by itself is useless -- unless it's connected to a brain. The eye does not carry out its function by dumping optical information into a yawning chasm. Rather, the eye is hooked up to parts of the brain -- anatomically speaking, the eye is an extension of the brain -- and those parts contain circuits for analyzing the incoming visual material, for recovering the shapes and colors and motions in the world that gave rise to the stimulation of the eye. The perception of a world of colored 3-D objects, in turn, feeds into a system of categorization, allowing us to make sense of our experience, to impute causes to events, and to remember things in terms of their significant categories. And in turn, those categories themselves would be useless unless they were organized in service of certain goals, goals set by our emotions. Beginning with the eye, we have a chain of causation that leads to the study of faculties of mind, or modules, or subsystems, each of which can be seen as an adaptation akin to the adaptations in the organs of the body. Recent research has shown that aspects of the psyche that were previously considered mysterious, quirky, and idiosyncratic -- such as phobias, an eye for beauty, the tendency to fall in love, a passionate desire for revenge in defense of honor -- turn out to have a subtle evolutionary logic when they are analyzed in the way in which we have always analyzed the organs of the body.

I find these developments to be exhilarating; they are a fulfillment of the ancient imperative to know thyself. They also have important practical implications. Alzheimer's Disease, to cite just one example, will be one of the leading causes of human misery in the industrial world over the next several decades, as we live longer and stop dying of other things. Successful treatment of Alzheimer's will not come from prayer or wishful thinking or reasoning about soul one; it will come from treating memory and personality as biochemical phenomena.

Nonetheless, as I mentioned at the outset, not everyone shares this excitement. Sometimes the reaction of people who learn about these new sciences is uneasy ambivalence. The American author Tom Wolfe wrote an article called "Sorry, But Your Soul Just Died," a mixture of admiration and apprehension over the frontiers of cognitive neuroscience and evolutionary psychology. A reviewer of my book *How the Mind Works*, alluding to the rock and roll band, said that I was describing people as Meat Puppets, and several reviewers, to my puzzlement, asked whether, if I were right, life would be worth living. I am puzzled by these reactions, which are never backed up by argument, only by indignation and high dudgeon. But I'll do my best to recover the values and reasoning that lead to them, and to show why I think they are misguided.

One reason I find the reaction strange is that I can't imagine how anything coming out of the laboratory, computer, or theoretician's notebook could possibly subtract from what is the meaning of life, or Richard's sense of Soul two. Why keep on living if our minds are the physiological activity of the brain? Well, for starters there's natural beauty, and works of great art, and ethical ideals, and love, and bringing up children, and enjoying friends, and discovering how the world works -- I could go on. Why should the worth of any of those activities depend on the existence of a ghost in the machine?

Clearly there can be reasons that some people feel threatened by the idea that the mind is the activity of the brain, and here are my guesses about what they are. One is that since natural selection is not a process that is guaranteed to produce niceness, many typical human motives will not necessarily lead to ethically desirable outcomes. Much of the research in evolutionary psychology has shown that many ignoble motives have some basis in natural selection. An example is the desire, most obvious in men, to defend one's honor and reputation, by violence if necessary. Another is the characteristically male motive to seek a variety of sexual partners. It's easy to work out why those motives evolved, and there is by now an enormous body of evidence that they are widespread among humans. But people reject the explanation because of what they think is the subtext. If these motives are part of our nature, if they come from the natural world, well, everyone knows that natural things are good -- natural childbirth, natural yogurt, and so on -- so that would imply that promiscuity and violence aren't so bad after all. And it implies that since they are "in the genes," they are unchangeable, and attempts to improve the human condition are futile.

I think both parts are wrong -- the first part is so obviously wrong that it has been given a name, the naturalist fallacy, the idea that what we find in nature is good. What we find in nature is not necessarily good; as Richard has put it, the universe is not good or bad, it's indifferent. Certainly violence and philandering and all of the other sins are immoral whether their cause is the genes, or the wiring of the brain, or social conditioning, or anything else. It behooves us to find the causes, but the causes don't change the moral coloring of those acts.

Also, the human mind, I argue, is a complex system of many interacting parts. Even if one motive impels people to do immoral acts, other parts of the mind that can subvert its designs. We can think of the long-term consequences, and we can imagine what society would be like if everyone acted on a particular motive. The part of the mind that has those thoughts can disengage the part of the mind that has less noble motives.

I think a second discomfort with the biological approach to the human mind is the worry that it somehow makes our ideals a sham or less real. Life would be a Potemkin Village, where there's only a facade of value and worth, but really biology is showing that there's nothing behind the facade. For example, if we love our children because the genes for loving children are in the bodies of those children and so the genes are benefiting themselves, doesn't that undermine the purity or the value of that love? If our ethical ideals, our sense of justice and fairness, were selected for because it did our ancestors good in the long run, would that imply that there's no such thing as altruism or justice, that deep down we're really selfish?

I think that this reaction is based on a misreading of Richard's metaphor of the selfish gene. It's not because of what Richard actually said in his book *The Selfish Gene*, which is crystal clear. But here's how it could be misread: the theory says that one can make powerful predictions about the process of natural selection by imagining that the gene has a selfish motive to make copies of itself. Of course no one ever thought that a gene has real motives in the sense that people have motives, but it this is a valuable way to gain insight about the subtleties of natural selection, especially when it comes to social interactions, and it leads to many correct predictions.

Here is the distortion. People think that genes are our deepest hidden self, our essence, so if our genes are selfish, that means that deep down *we're* selfish. It's an unholy hybrid of Freud's idea of unconscious motivation and the straightforward modern theory of the natural selection of replicators. Now, I think I'm safe to say that it was not intended by Richard, and it doesn't follow from the logic of the theory. The metaphorical motives of the genes are not somehow a more fundamental or honest version of the real motives of the entire person. Indeed, sometimes the most "selfish" thing a gene can do, in this metaphorical sense of selfish, is to build a brain that is not selfish -- not selfish at an unconscious level, not selfish at any level -- even if the genes are themselves metaphorically selfish. When we love our children we aren't at any level of the brain calculating that it will increase our inclusive fitness. The love can be pure and in and of itself in terms of what's actually happening in the brain. The selfishness of genes explains why we have that pure emotion.

The idea that morality itself would be a fiction if our moral reasoning came out of some evolved moral sense is also a non sequitur. The fear comes from the fact that we know that many aspects of human experience are in some sense figments. The qualitative distinction between red, yellow, green, and blue, for example, is not out in the world; it's just the way our brain imposes arbitrary cuts in the continuous spectrum of the wavelength of light. Well, if the qualitative difference between red and green is a figment -- it's just the way we're built, it doesn't have any external reality -- could right and wrong also be a figment? Would the sense of worth that comes from pursuing justice and fairness be a sham, just a way of tickling our pleasure centers and making us feel good because of the flow of chemicals or the wiring diagram of the brain?

Not at all. This supposed devaluation of morality does not follow from the idea that we have an evolved moral sense. Many of our faculties evolved to mesh with real things in the world. We have a complicated system of depth perception and shape recognition that prevents us from bumping into trees and falling off cliffs. The fact that our ability to recognize an object comes from complicated circuitry of the brain does not mean that there aren't real objects out there. Indeed, the brain evolved in order to give us as accurate a representation as possible of what is objectively out in the world.

That may also be true, at least according to some philosophical arguments, for morality. Many philosophers believe that some abstract entities, such as numbers, have an existence independent of minds. That is, many philosophers and mathematicians believe that the number three is not just a figment in the way that the color red is, but that it has a real existence, which mathematicians discover and explore with their mathematical faculties; they don't invent it. Similarly, many moral philosophers argue that right and wrong have an existence, and that our moral sense evolved to mesh with them. Even if you don't believe that, there's an alternative that would make the moral sense just as real -- namely, that our universal moral sense is constituted so that it can't work unless we believe that right and wrong have an external reality. So if you want to stop short of saying that moral truths exist outside us, you can say that we can't reason other than by assuming that they do. In that case, when we get down to having a moral debate, we still appeal to external standards of right and wrong; we aren't reduced to comparing idiosyncratic emotional or subjective reactions.

The final disquiet, I think, that is elicited by the naturalist or biological approach to the mind, is that it robs us of responsibility. If we act only because of ricocheting molecules in the brain, shaped by the genes which in turn were shaped by natural selection -- if it's billiard balls all the way down and all the way back -- then how can we hold someone responsible for his actions, given that there is no "he" that caused them? I agree this is a fascinating puzzle, but I don't think it has anything particular to do with cognitive neuroscience or behavioral genetics or evolutionary psychology. It's a problem that is raised by *any* attempt to explain behavior, regardless of the nature of the explanation. You all remember the scene in "West Side Story" in which the gang of juvenile delinquents explains to Sergeant Krupke, "We're depraved on account of we're deprived":

> "Dear kindly Sergeant Krupke, You gotta understand, It's just our bringing up-ke, That gets us out of hand. Our mothers all are junkies, Our fathers all are drunks. Golly Moses, naturally we're punks!"

Sondheim's lyrics send up the psychoanalytic and social-science exculpations of bad behavior that were popular in the 1950s, and the non-biological excuses continue. In the 1970s, Dan White was given a light sentence for murdering the mayor of San Francisco because his mind was addled from too much junk food, the infamous Twinkie Defense. In the 1990s, the lawyer for the Menendez brothers argued her way to an acquittal based on her client's diminished responsibility because of childhood sexual abuse. Any time someone explains behavior, biologically or otherwise, a thoughtless observer can imagine that the explanation absolves the actor of responsibility. According to an old saying, to understand is not to forgive. If a moral system locates responsibility in a ghost in the machine, we need to revise the moral system, because the ghost is being exorcised, but we still need the notion of individual responsibility. Any ethical theory that is challenged by some outcome from the laboratory is a defective, or at least an incomplete, ethical theory.

Yesterday I was on the radio with a professor of divinity who said it was crucial that we retain the idea of a unified self, a part of the brain where it all comes together -- the ethical system of two billion people depends on it, he said. I replied there's considerable evidence that the unified self is a fiction -- that the mind is a congeries of parts operating asynchronously, and that it's only an illusion that there's a president in the Oval Office of the brain who oversees the activity of everything. He said, "I hope that's not true, because if it is we'll have to change our ethical system." I think this is an unwise way of doing moral reasoning. He might be right; I suspect that he's wrong; but whether he's right or wrong, we don't want the morality of killing and raping and lying and stealing to depend on what comes out of the psychology lab down the hall. We need our ethical system to be more robust than that -- it's always wrong to kill people, and we need an ethical system for which that's axiomatic.

To conclude -- we look with wry amusement at the debates in cosmology of three or four hundred years ago, in which great moral significance was attached to the debate between the geocentric and heliocentric theories. It was considered not to be just an empirical question of science, but a problem of great moral weight whether the earth went around the sun or the sun went around the earth. Now we look back and see that this was all rather silly. Either one theory is true or the other one is true, and people had to find out which is which. Any notion that meaning, purpose, ethics, morals and so on hinge on that contingent fact of cosmology came from unsound reasoning. I suspect that the idea that meaning, purpose, and morals hinge on a Soul one, a ghost in the machine, will have the same fate. The ghost in the machine has been exorcised, and meaning and values are none the worse for it. Thank you very much.

RADFORD: If there is a sense of good which is independent of us, who put it there? If a sense of god is a product of evolution, why do we all have such a consistent idea of a divine experience. When one reads the lives of the saints, one comes across the same phenomenon. We can't all have the same brains, or we don't all have the same brains -- why are all these things -- I know these questions are going to be asked, so I'll get them in now, if you don't mind. Richard? Or who wants to start with that one.

PINKER: As for the first question, who put them there -- it may be like the question, "Who put the number three there?" It would be best to get a real moral philosopher to defend the theory of moral realism, but I'll do my best. Perhaps morality comes from the inherent logic of behavior that has consequences for other agents that have goals. If one of the goals is to increase total well-being, then certain consequences may follow in the same way that the Pythagorean theorem follows from the construction of a triangle. Moral truths may exist in the same sense that mathematical truths exist, as consequences of certain axioms. That's my best rendition of the premises of a theory of moral realism.

As for the second question, why do so many people and cultures end up with similar views of a deity or spiritual theme? -- these beliefs may come from two mental faculties that may not have evolved specifically for spiritual belief, but may have evolved for other things, and as a byproduct give us particular notions of gods and deities. One of them is what psychologists call a "theory of mind"; by "theory" they don't mean a scientist's theory but a folk theory. We all tacitly subscribe to the "theory" that other people have minds. We don't think of other people as mechanical wind-up dolls. Even though we can't know what someone else is thinking, we do our best to make guesses. We look at their eyes, we read between the lines, we look at their body postures, and we assume that they have minds, even though we can't see them directly. Well, it's a short step from imputing an unverifiable entity called the mind to another body, to imputing a mind that exists *independently* of a body. Beliefs in souls, spirits, devils, gods, and so on, may be the products of a theory of mind or intuitive psychology that has run amok, and is postulating entities divorced from their physical home.

The other part of the explanation comes from a conclusion that anthropologists have drawn about what you find in common in all the world's religions -- not just the major proselytizing religions, but the animistic beliefs of hunter-gatherer tribes. Ruth Benedict put it succinctly: the common denominator of religions is that a religion is a recipe for success. She didn't necessarily mean this to apply to the most sophisticated theologies, but in general, what people do in common when they think of deities is to pray to them for recovery from illness, for recovery from an illness of a child, for success in love, for success on the battlefield, for good weather, for the crops coming up, and so on. I don't want to say that sophisticated theology can be reduced to praying for good weather, but if you look at what's common across cultures that's what you find.

RADFORD: Richard?

DAWKINS: I think that there's been a historical trend from animism where every tree and every river and every mountain had a spirit, to polytheistic religions where you have Thor, and Wotan, and Apollo and Zeus and things, then a trend towards monotheism (and finally zerotheism or atheism). Interestingly enough I was looking into the law of charity the other day, and found that one of the things that defines a charity for tax purposes is the furtherance of religion. But in British law it's got to be monotheistic religion. Now, there's a large Hindu population in this country. I imagine they might have something to say about that.

But I was actually wanting to steer the question in another direction. Having worked from polytheism to monotheism, I wanted to use that as an analogy in a quest to try to derive some joint enlightenment by talking to Steve about something -- actually, I want to learn something from Steve. So may I change the subject? You, Steve, talked about the illusion that the mind is a unity. Now, I imagine what lies behind your saying that it's an illusion is that actually there is in the mind a whole lot of entities which are actually pretty distinct. They may be even be pulling in different directions, but I imagine that there's been some Darwinian benefit in the move from poly-minds to mono-mind. There's a book by a South African biologist, Eugene Marais, *The Soul of the White Ant.* "White ants" are termites. Any social insect colony behaves in some ways like a single entity. It's as though it's got one purpose. Actually, of course, it's thousands of little worker termites, all doing their own little thing. And no one termite has any general concept of the whole picture, so when the termites build these huge great mounds, each individual termite is just following little tiny rules. If you see a bit of dirt of such and such a height, put another bit on top of it. There are rules which, when summed over all of the termites, lead as an emergent property to the growth of the mound as a whole. A final strand in this argument goes back to the genes. The fundamental message of the selfish gene is that genes are separate entities all pulling their own way in their own separate selfish way. But yet we have this gathering together of genes into individual organisms. And that reminds me of the illusion of one mind, when actually there are lots of little mindlets in there, and the illusion of the soul of the white ant in the termite mound, where you have lots of little entities all pulling together to create an illusion of one. Am I right to think that the feeling that I have that I'm a single entity, who makes decisions, and loves and hates and has political views and things, that this is a kind of illusion that has come about because Darwinian selection found it expedient to create that illusion of unitariness rather than let us be a kind of society of mind?

PINKER: It's a very interesting question. Yes, there is a sense in which the whole brain has interests in common in the way that say a whole body composed of genes with their own selfish motives has a single agenda. In the case of the genes the fact that their fates all depend on the survival of the body forces them to cooperate. In the case of the different parts of the brain, the fact that the brain ultimately controls a body that has to be in one place at one time may impose the need for some kind of circuit, presumably in the frontal lobes, that coordinates the different agendas of the different parts of the brain to ensure that the whole body goes in one direction. In *How the Mind Works* I alluded to a scene in the comedy movie *All of Me* in which Lily Tomlin's soul inhabits the left half of Steve Martin's body and he takes a few steps in one direction under his own control and then lurches in another direction with his pinkie extended while under the control of Lily Tomlin's spirit. That is what would happen if you had nothing but completely autonomous modules of the brain, each with its own goal. Since the body has to be in one place at one time, there might be a circuit that suppresses the conflicting motives. And in cases of neurological disease or brain damage, and even perhaps in psychiatric conditions, we may be seeing a relaxation or an imbalance or a defect in some of the mechanisms that coordinate different parts of the brain. Perhaps in an obsessive-compulsive disorder, motives that we all have, such as checking to make sure that the stove is off and washing our hands, ordinarily might be repressed by some other part of the brain that says "yes, it's good to do that, but not too much; there are other things to do as well." Obsessive-compulsive disorder may come from an imbalance among these different mechanisms.

QUESTION: I just wanted to bring up the very obvious point of biological reductionism which I think is raised by some of the speakers here -- in that while I agree about there being no ghosts in the machine I'm a little bit worried about what it's getting replaced with is seemingly a rather simplistic way of looking at the world as being the outpourings of the human genome project. And in that, I'm worried that I don't hear for example that human behaviors like aggression and so forth are the product of very social processes, shared processes, between groups, between people who are unfamiliar with one another, who have misperceptions of one another and so forth -- the kinds of processes that social psychologists talk a great deal about. What we're being offered instead is a sort of reductio ad absurdum biological form of reductionism. Are we just going from one form of ghost to another. It's not a ghost, but a rather simple way of looking at the world.

PINKER: I don't think any complex behavior can be explained directly in terms of the genes, which is why I emaphasized evolutionary psychology and cognitive neuroscience. Behavior is produced by the trillion-synapse human brain, which assesses situations, absorbs values from the people that we grow up with, assesses the long-term consequences of actions, tries to impress other people, and many other things. All of the phenomena that we call culture are real and utterly indispensable, but they have to be connected to the emotional and learning mechanisms that our brain makes available. I think any behavior has to be explained at many levels; our inborn emotions and learning mechanisms are one important level, perhaps the most important level, but not the only level.

RADFORD: Can you break the notion of culture down into a reductionist argument?

DAWKINS: Reductionism is one of those words that makes me want to reach for my revolver. It means nothing. Or rather it means a whole lot of different things, but the only thing anybody knows about it is that it's bad, you're supposed to disapprove of it.

QUESTION: What we need is for science, cognitive science in particular, to evolve further, so we begin to grasp the mystery that is subjective experience. Dr. Pinker said that the mind is the activity of the brain, and went on to describe ways in which cognitive neuroscience etc explained that. But in a way -- I can't help thinking of the analogy of the television set. It would be naive to suppose that the program that you watch is actually produced within the television set, and yet somebody from another planet who didn't know about television might assume that the program was generated within the television set.

DAWKINS: Steve can give a serious answer; I'm going to say something about television sets. My friend Douglas Adams has a wonderful story about television sets. He imagines somebody who believes that there's a little man inside the television set who's juggling the pictures and making it all happen. Well, he's taken on one side, and it's explained to him all about cathode ray tubes and scans and radio waves, and the whole principle about television sets is explained to him, and he nods and he says, yes, yes, I think I've got that, right, I understand that, hmm, very interesting. But I expect there are just a *few* little men in there, aren't there?

PINKER: I want to distinguish what is truly mysterious about consciousness from what is merely an unsolved scientific problem in the process of being solved. Obviously consciousness is not a total mystery, because when you go in for surgery a man puts a mask over your face and gas comes in and he can on demand make you unconscious and bring you back to consciousness. More generally, we are learning more and more every day about the neural basis of consciousness -- what goes on in the brain when you have a conscious experience -- down to itty bitty details: why one thing looks redder or tastes saltier than another, and countless other details of perception, memory, and emotion. The part that remains a mystery is why the purely subjective aspect of experience should exist at all. Some philosophers, such as Dan Dennett, argue that that isn't a scientific problem and may not even be a coherent question -- since, by definition, pure subjective experience has no observable consequences, we're wasting our time talking about it. I think that goes too far, but it is possible that the existence of subjective first-person experience is not explainable by science. When cognitive neuroscience completes the story of how the brain works and predicts every last itch, every last nuance of color and sound in terms of the activity of the brain, one can still wonder why it *feels* like something to see and touch and taste.

My own hunch is that this unsatisfied curiosity may itself be an artifact of how our brains work. It may be a question like "What occurred before the Big Bang?," or "What's outside our finite universe," or "What does a 4-dimensional object look like?" The puzzlement may come from a mismatch between our ways of thinking and knowing and the nature of reality as revealed by our best science. Our brains are organs that think and know in particular ways, and if they cannot come to grips with the discoveries of our best science (such as the discovery that brain activity causes subjective experience), that may just be our problem, a limitation of our own common-sense intuition in fully appreciating the lessons of our science. The science itself may be fully complete.

DAWKINS: It stills feels like a hell of a problem to me.

QUESTION: I want to ask about the problem of free will. It seems to me an implication of what you're both arguing that free will may be an illusion. Have I misunderstood?

PINKER: Again, it depends on what the meaning of "free will" is. I don't mean to sound like President Clinton -- but there's "free will" in the sense of the Soul one, the ghost in the machine, an utterly capricious and unpredictable process, an absence of even statistical predictability, where you just can't tell what someone is going to do. In that sense, as soon as you understand something about human behavior, and as soon as you can predict something about behavior, free will has evaporated. I think that sense of free will doesn't exist. On the other hand, there may be a sense of free will that we need as a construct, or an idealization in our system of moral reasoning, to get the answers to come out right. We may want to distinguish between people who are literally in a fugue state and hallucinating, and people who are compos mentis and who can be held responsible for their actions in the mundane sense that punishment may deter them and others. It may be that free will is the most convenient way of summarizing that difference, in which case it would continue to exist, but in a scientific translation, that is, a brain state within certain normal conditions.

QUESTION: Professor Dawkins, at the start of your talk, you said that the traditional religions were not only false but also failed to provide a deeper meaning than science and in that sense were not more soulful. I agree with that, to the extent that they attempt to provide an explanation, but another thing that the religions do is give comfort to people if they lose people in car accidents or to cancer and so on, and as far as I've experienced it, the scientific view cannot give people this kind of comfort. So in that sense the religions, even if they're false, are more soulful. And I wonder how you would respond to that.

DAWKINS: I think there is a lot in that. I of course was talking about that aspect of religion where the psalmist says the heavens declare the glory of God. Science can do a lot better than that. The questioner is asking about another thing that religion can do, which is consoling people in bereavement and similar situations. On that I would say three things. First, I mainly agree with you. Science is not on the whole going to console you if you lose a loved one. The second thing I would say is that the fact that religion may console you doesn't of course make it true. It's a moot point whether one wishes to be consoled by a falsehood. The third thing I would say is that although science may not be able to console you in the particular case of a bereavement from a car accident, it's not at all clear that science can't console you in other respects. So, for example, when we contemplate our own mortality, when we recognize that we're not here forever and that we're going to go into nothingness when we die, I find great consolation in the feeling that as long as I'm here I'm going to occupy my mind as fully as possible in understanding why I was ever born in the first place. And that seems to me to be consoling in another sense, perhaps a rather grander sense. It is of course somewhat depressing sometimes to feel that one can't go on understanding the universe; it would be nice to be able to be here in 500 years to see what people have discovered by then. But we do have the privilege of living in the 20th and very soon in the 21st century, when not only is more known than in any past century, but *hugely* more than in any past century. We are amazingly privileged to be living now, to be living in a time when the origin of the cosmos is getting close to being understood, the size of the universe is understood, the nature of life in a very large number of particulars is understood. This is a great privilege; to me it's an enormous consolation, and it's still a consolation even though it's for each one of us individually finite and going to come to an end. So I'm enormously grateful to be alive, and let me take up what Steve was talking about, the question of how you can bear to get up in the mornings. To me it makes it all the more worthwhile to get up in the mornings -- we haven't got that much time, let's get up in the morning and really use our brief time to understand why we're here and what it's all about. That to me is real consolation.

QUESTION: Both of you seem to agree that science has killed off Soul One; I agree with you. Just to play devil's advocate a little bit: it obviously hasn't killed off the *belief* in Soul One and it's possible that it will never do so -- in the sense that a world in which no one believed in Soul One would not be what you called an ESS, an evolutionarily stable state. In other words, just as a world in which everybody was nice to each other is not an evolutionarily stable state, because cheats prosper -- it may be that a world in which nobody believed in Soul One would be a fantastically fertile breeding ground for cults who did believe in Soul One. If that's the case then you'll never get rid of it.

RADFORD: Who wants to deal with the New Age question?

DAWKINS: Yes. G. K. Chesterton said when people stop believing, they don't believe in nothing, they believe in anything. I presume that's what the questioner has in mind. I am interested in cults. The so-called organized religions are of course just old cults. They started off as cults and they've acquired a respectability that's simply due to the long time that they've been with us. I'm interested in them. I don't know why the questioner thinks it's not an ESS. It's not to me obvious that a world in which nobody believed in Soul One is necessarily ripe for invasion by cults, except insofar as I think one of the main reasons why people do believe the things that they believe is somewhat analogous to viral infection. And the reason for this has a good Darwinian basis. When we are children it is very important that we should learn as quickly as possible certain extremely important things. The language of our society, the social rules of our society, various rules for how to stay alive in a hostile world. So it's very easy for a Darwinian to believe that children will be preprogrammed with a rule that says, Believe what your parents tell you, or believe what your society's elders tell you. And of course a rule like that is not going to be discriminating. It's going to work both for the sensible things -- rules for how not to die of snake bite or falling off of cliffs or how to learn the language of the society. But the self-same rule is also going to be a natural sponge, or a natural soaker-up of New Age nonsense, and nonsense of any other kind.

So, a biologically sensible rule -- Believe what you're told when you're young, and when you grow up pass on the same stuff to your own children -- that is a recipe for the long-term survival for the beliefs themselves. Or the rule might be, Believe so-and-so, and spend as much time as possible persuading other people to believe it as well; that's a recipe for epidemics of infectious beliefs. So I think that in that sense I agree with the questioner.

QUESTION: I followed what Richard Dawkins has said over the years and I admire him for his defense of science, but in the end, I think -- as Engel would say it, in a reaction against theology etc., we can come to an explanation it's very one-sided; and I think with Steven Pinker, I'm surprised that he's surprised that people don't accept his theories, because after all we're dealing with consciousness, which is social and historically developed over millions of years of human society, and you can't say in the end that that resides in people's genes. If we take the example if you say about morality -- surely morality is something that's been developed over the years. Why is it that in America we get individuals that go out shooting people -- surely that's a symptom of American society.

RADFORD: You've just raised a huge question, which could keep us happy all night, I'll try to get our two guests to answer it. Why do things go wrong? The question is a serious one. If evolution is for the best, if a religious sense provides us with the stability to go through life, why do things go wrong? There's a whole Robert Bresson film devoted to this one, it's called *The Devil Probably*; there's a Kurt Vonnegut statement as well. Who wants to take this one on?

DAWKINS: That's not what I gathered the question was. Nobody's ever said evolution is for the best, except insofar as it's for the best of the genes, and that's another matter. I don't think there was a question there at all; I think that was a statement, which we should be grateful for.

PINKER: I think that evolution and genetics and neuroscience are essential parts of an explanation of human behavior, but that doesn't mean that people are sealed in a barrel, oblivious to the standards of behavior set by other people, and unable to make decisions based on them. Quite the contrary -- one of the things our brains are designed to do is learn the contingencies of the social world we find ourselves in. Obviously there is variation among cultures, which is made possible by the fact that people innovate and people learn other people's innovations. Also, the optimal way to behave in a given situation depends on how other people behave and react to one's own behavior, and those contingencies vary from place to place and have to be learned. There are large differences, orders of magnitude, in rates of violent encounters across different countries, although the psychology of the violent encounters is strikingly similar. The rates differ because of differences in the cultures and social values, those values aren't like a gas that seeps out of the earth and that people merely breathe in. They emerge from a bunch of minds interacting in a group, exchanging ideas, assessing one another, making decisions. So culture itself, even though it's part of any explanation of behavior, itself has to be tied to the psychological and ultimately neurological mechanisms that allow cultures to arise to begin with.

THE REALITY CLUB

Jaron Lanier on Daniel C. Dennett's The Evolution of Culture

From Jaron Lanier
Submitted: 4.1.99

There are a number of frustrations confronting a skeptic who attempts to make sense of the claims made by adherents of the "meme" idea. First and foremost among these is that the notion is so variable as to provide no fixed target. In my conversations with Richard Dawkins, including one that was transcribed and published (click here), I have had the distinct impression that his ambitions for the term are modest. He wonders if *some* cultural processes could be understood as being like selfish genes. This caution is also found among certain other theorists, who focus on unconscious or semi-conscious phenomena like dance steps as candidate memes. Some meme-adherents (click here) demand a rather strict application of the metaphor to genes, while others, including Dennett, are ready to explore alternate biological models, such as viruses. Then there are meme totalists who believe their one metaphor consumes the whole of culture. Most perplexing is the fact that individual meme proponents display a tendency to waver between these preferences according to who is in the audience. I have more than once had the experience of watching a meme totalist turn into a guarded meme speculator when confronted by a skeptic, only to expand again once the skeptic left the room.

Are memes a rhetorical technique, a metaphor, a theory, or some other device? Depending on who you talk to, they can be so wispy as to be almost nothing. As applied by Dennett in his lecture, they make no predictions and cannot be falsified. They are no more than a perspective. Just as a musician might try to listen to the silences, instead of the notes, to gain a new experience of familiar music, Dennett asks us to consider culture from the point of view of tropes instead of people.

I adore this exercise for it's esthetic value. As a young composer I used to use my imagination to take on the identities of musical ideas. Imagine being equal temperament. You would first come to consciousness in China and feel yourself pounded out into the air from giant bells. You would feel the dark beating of your imperfect harmonies like tingles in your toes. Then, with the death of an Emperor, you would fall into a deep sleep, only to awaken centuries later pulsing out of the fingertips and into the ears of a frenetic, sober, workaholic named Bach. You would then feel your body opened up in new ways by a prying cosmic chiropractor- this is how the successive generations of harmonic innovators would feel to you. You would eventually flow out of the Beatles' space age chrome guitar pickups and through the distorting diminutive speakers of pastel plastic Japanese radios.

Since neither Dennett nor anyone else identified with the meme movement is unambiguous about what they are claiming, I'll answer Dennett's lecture in a similarly schizophrenic fashion. First, I'll assume memes are poetry, then I'll assume they are theory.

If memes are poetry, then they are the poetry of a flight from Meaning. What is communicated in Dennett's account of the origin of music is primarily that it means nothing. Imagine for a moment that instead of music, Dennett had chosen to provide a "just so" story to explain the origin and development of mathematics.

Dennett could have started in the same way, with an early hominid or some other ancestor beating a stick for the hell of it, only in this case he or she would have done so for a certain number of times. The "integers" meme was thus born. Dennett could have created a scenario in which that beating is copied and elaborated and gains its own momentum. This could develop in the course of millennia into an elaborate culture of counting, including strange kinds of numbers, like the imaginaries. It would also explain the often noted concurrence of musical and mathematical talent.

But something would be missing, which is that mathematical ideas can actually be true or false. In the same way, I am not ready to throw out the possibility that musical meaning is not entirely culturally relative. As Dennett points out, "music" is a universal phenomenon. It is probably the only human activity that is both universal and apparently elective. Yet the variety of musical behavior is so extreme as to make one wonder how it is possible for humans to perceive that universality.

By what stretch of the imagination is Inuit throat singing (which is accomplished by two people kissing and using each-others' throats as resonators) in the same category as John Cage sitting quietly in front of a piano, or Stanford students staying up all night perfecting a new signal processing algorithm?

As much as Dennett wants to get rid of ontology, he is its slave. He relies on meaning in order to communicate his attack on meaning. How can he even talk about music? Music is not the only pattern of behavior that has become extremely elaborate. Everyday greetings and small talk are extremely complex, and yet are not experienced as profound.

What is this profundity, this meaning in music? Well, that's the hard question. Music is particularly odd because it sits at the intersection of so many aspects of human experience and capability. It is a little like math, a little like dance, a little like sex, a little like speech, a little like drama. It is all these things and yet it is somehow instantly recognizable as something distinct.

I can report subjectively that in extended work with other musical cultures, there is an eerie sense of common musical understanding that is somehow possible. In learning to play musical instruments from distant cultures I have had the distinct impression of entering a heretofore inaccessible world of experience- as if learning to move and breath with these artifacts conveyed qualities that words and even sounds could not. And yet it is of course impossible to be certain of how much commonality I have ever truly achieved, or indeed if there was as much distance as I initially perceived. I can't know how much of the musical meaning I experience is illusory, except to say that I believe it to be absurd to think that it is entirely an illusion. To assert illusion is ultimately to assert both meaning and consciousness; an unconsciously had, meaningless illusion is an absurd proposition. Such a thing could not be detected.

The question of meaning is one that Dennett is simply deaf to. It is a subjective pleasure, like consciousness. It is part of that world of things that cannot be empirically falsified, but undeniably constitute an individual's subjective reality. A person's rapture at the hearing of Bach's music can theoretically be characterized neurologically, and could then be emulated by a computer. That the experience itself exists is known only to each individual experiencer.

I have speculated elsewhere (click here) that Dennett might represent a class of person who does not have internal experience. I meant this originally as a joke, and I still strongly suspect that he and other "cybernetic totalists" are merely enjoying being smart alecs by tweaking those of us ready to acknowledge that we have subjective awareness. But the logical possibility exists that there are some people without internal experience, and that would certainly explain our diverging philosophies.

Instead of trying to make the question of meaning disappear in the mists of a single metaphor, science can better proceed by gradually helping to illuminate components of meaning that can be subjected to empirical investigation. A genetic component for such a universal phenomenon as music would not be surprising, and indeed it has been proposed. For an example click here. It might at first seem surprising to see Dennett, of all people, not even mention the work that has been done suggesting genetic components to musical behavior, but it shouldn't be. The alliance between information centric theorists and biological determinists is probably a temporary marriage of convenience. Soon enough, I expect, meme theories will cause simplistic cybernetisists to jump over to the cultural relativity side of the fence en masse.

There is an irony here. Dennett seems to be arguing that under a Darwinian lens, culture would look like a "spandrel", which was a metaphor constructed by Stephan J Gould and rather violently repudiated by Dennett.

Now, what of memes as theory rather than poetry? I have addressed this already elsewhere in the Edge dialogs (click here - see bottom of the page). So I will only summarize here.

Objection #1) There are no predictions that can be tested, no potential for falsification. Memes are, as Dennett points out, open enough in their possibilities to account for the wild variations imaginable in potential cultures. But there is no basis for preferring memes over other potential equally open theories. Are memes more testable than the vague obfuscations of recent "postmodern" philosophers? Or do they merely adopt a cybernetic style that certain people find more comforting?

Objection #2) Ideas and other cultural elements are Lamarckian. That is one reason why people didn't understand Darwin at first. God was supposed to have thought the world into existence. Even people who were ready to question God had trouble getting over the idea of ideas. Indeed, I have seen students adopt incorrect understandings of genes because of the publicity for memes. They thought that genes must work like ideas, and be able to influence each other on contact. Lysenko would have loved memes.

Objection #3) Ideas often have objective value. Mathematical ideas can be proved. Scientific theories can be falsified. Technologies can function, or fail. Political ideas have harder to assess but real moral and ethical implications. A candidate for a virulent meme, such as the music for a Diet Pepsi commercial, might truly be a lesser achievement than, say, a late Beethoven string quartet- yet that judgement cannot exist in the framework of memes alone. Furthermore, in all of the above cases people have created cultural institutions that have formally, rationally improved human achievement in the course of history. Culture is a watchmaker with vision, at least some of the time.

Objection #4) Culture doesn't generally suffer from constraints of the sort found in biological processes. For instance, bad ideas typically don't really die, alas, while the dominant mechanism of evolutionary selection is pre-reproductive death (the other primary mechanism being mate selection). Your genetic traits were largely selected for because your would-be ancestors with alternate traits were killed by your actual ancestors or other organisms, particularly microorganisms- or starved to death. In that sense, the ideas that perished in the library at Alexandria were more like memes than any ideas in currency today. Furthermore, culture doesn't generally have impassable species boundaries. Although cultures become isolated on occasion, in a vast number of cases ideas flow into one another and selection pressure, if it existed, could not be focused on a unit of potential change, as it is in biological systems.

Objection #5) Ideas and other cultural phenomena do not necessarily have an inheritable substrate that functions as a specification layer. Biological organisms are reducible to an evolutionary interpretation to the degree that traits are described by genes. (As in: An undernourished animal will be smaller than a well nourished genetic twin, so not all observed traits are genetic.) In order for a meme theory to say anything it would have to be able to identify some structure that could serve as the basis for reductionism. It is possible that some human behaviors are not reducible. (In my experience, for example, you cannot learn to play Indian classical music without becoming immersed in Hindu culture, including a style of movement, of interpersonal and intergenerational contact, and a great many other things that do not have names.)

Jaron Lanier

EDGE IN THE NEWS

MIND MELD

Literary agent John Brockman gives intellectuals an Edge

By Tom Samiljan
Time Out New York
April 8-15, 1999 Issue No. 185

Now that AOL's mass-market muscle has taken over the online world, it's easy to forget that the Net has long been a forum for intellectuals to exchange ideas. The problem is that many of these ideas are debated on exclusive, invitation-only mailing lists. But on Edge, the brainchild of New York literary agent John Brockman, the musings of some of the world's most prominent academics, artists and scientists‹on topics as varied as genetics and affirmative action‹are available to anyone. Getting on the list can be tough (you have to know Brockman), but mere mortals can access edited archives of his high-minded monthly e-mail newsletter at Edge's website.

Brockman launched the Edge list in 1996 as an online incarnation of the Reality Club, a group of intellectuals who began meeting in 1981 in real-world salons. "I started the Reality Club because it's almost impossible to sit down in New York and think deeply," says Brockman. "This is a market town‹it's hard to get a group together to focus on serious works." Now Brockman gathers minds from around the world for online discussions and writings about such topics as relativity theory and Plato. In Edge's 52 monthly editions thus far, surfers can find, for example, transcripts of lectures given by Darwinian theorist Richard Dawkins and interviews with MIT computer scientist Marvin Minsky and musician Brian Eno.

Probably the most stimulating and attention-grabbing content has resulted from the site's periodical posing of portentous philosophical questions. In a recent edition from January, Brockman asked his mailing-list members to identify the most important invention of the past 2,000 years. Among the responses were the eraser ("because it allows us to go back and fix our mistakes," according to *Ecstasy Club* author Douglas Rushkoff), the clock ("It converted time from a personal experience into a reality independent of perception," writes Disney Imagineer Danny Hillis) and Copernican Theory ("It took a lot of intellectual courage and taught us more than just what it said," writes the Monkees' Michael Nesmith). Such answers, along with 600-odd postings on the same topic from visitors to Edge's discussion area (run separately by New York-based e-zine Feed at www.feedmag.com), prove that shopping and fucking are hardly the only reasons people go online.

Brockman started Edge in response to the notion of the "third culture," an idea described by C.P. Snow in his 1959 book *The Two Cultures*. Snow identified two types of intellectual cultures: literary and scientific. In the future, Snow posited, members of these groups would come together and form a third culture to disseminate intellectual concepts to the public. According to Brockman, however, the third culture that has emerged is more the result of scientists' becoming increasingly literate. "The literary world, which hijacked the word *intellectual,* has been brain-dead for 30 years. Now it's the scientists who are asking the big questions," says Brockman, citing the success of Brian Greene's *The Elegant Universe,* a book about string theory that hit No. 1 on Amazon.com's best-seller chart this past February.

Although it covers weighty scientific issues and has a recipient list that reads like a who's who of the digerati (including Bill Gates and *Version 2.0's* Esther Dyson), Edge is remarkably low-tech and text-based. The irony of this is not lost on Brockman. "[Even though I'm] someone who has been pushing the envelope for digital communication, I keep coming back to books," he says. "The power of the printed word is amazing."

Why the elite mailing lists? Brockman chalks it up to lack of manpower. "I try to do everything myself," he says. "If I started to read a bunch of [unsolicited] e-mails, then I wouldn't have time to do Edge." And since the site's content is available for free, the greater public doesn't really miss out. According to Feed founder Steven Johnson, in some cases, the clearly focused discourse of closed lists can be preferable to the sometimes incoherent and rambling nature of open forums.

Whether or not Edge visitors decide to chat intelligently about issues on Feed won't change the distinctive content of Brockman's salon. Visitors are guaranteed a look into the minds and theories of people who make a living lecturing around the world and writing books. And for the intellectually curious who don't have the time or money to attend thought-provoking symposia and conferences, Edge is easy on the wallet. At least Brockman thinks so. "I think I've created the best graduate school in the world," he says.

Visit Edge at www.edge.org.

John Brockman, Editor and Publisher | Kip Parent, Webmaster

Lament for Douglas
By Richard Dawkins
Article in The Guardian May 14, 2001

This is not an obituary, there'll be time enough for them. It is not a tribute, not a considered assessment of a brilliant life, not a eulogy. It is a keening lament, written too soon to be balanced, too soon to be carefully thought through. Douglas, you cannot be dead.

A sunny Saturday morning in May, ten past seven, shuffle out of bed, log in to e-mail as usual. The usual blue bold headings drop into place, mostly junk, some expected, and my gaze absently follows them down the page. The name Douglas Adams catches my eye and I smile. That one, at least, will be good for a laugh. Then I do the classic double-take, back up the screen. What did that heading actually say? Douglas Adams died of a heart attack a few hours ago. Then that other cliché, the words swelling before my eyes. It must be part of the joke. It must be some other Douglas Adams. This is too ridiculous to be true. I must still be asleep. I open the message, from a well-known German software designer. It is no joke, I am fully awake. And it is the right – or rather the wrong – Douglas Adams. A sudden heart attack, in the gym in Santa Barbara. "Man, man, man, man oh man," the message concludes,

Man indeed, what a man. A giant of a man, surely nearer seven foot than six, broad-shouldered, and he did not stoop like some very tall men who feel uncomfortable with their height. But nor did he swagger with the macho assertiveness that can be intimidating in a big man. He neither apologised for his height, nor flaunted it. It was part of the joke against himself.

One of the great wits of our age, his sophisticated humour was founded in a deep, amalgamated knowledge of literature and science, two of my great loves. And he introduced me to my wife – at his fortieth birthday party. He was exactly her age, they had worked together on Dr Who. Should I tell her now, or let her sleep a bit longer before shattering her day? He initiated our togetherness and was a recurrently important part of it. I must tell her now.

Douglas and I met because I sent him an unsolicited fan letter – I think it is the only time I have ever written one. I had adored The Hitchhiker's Guide to the Galaxy. Then I read Dirk Gently's Holistic Detective Agency. As soon as I finished it I turned back to page one and read it straight through again – the only I time I have ever done that, and I wrote to tell him so. He replied that he was a fan of my books, and he invited me to his house in London. I have seldom met a more congenial spirit. Obviously I knew he would be funny. What I didn't know was how deeply read he was in science. I should have guessed, for you can't understand many of the jokes in Hitchhiker if you don't know a lot of advanced science. And in modern electronic technology he was a real expert. We talked science a lot, in private, and even in public at literary festivals and on the wireless or television. And he became my guru on all technical problems. Rather than struggle with some ill-written and incomprehensible manual in Pacific Rim English, I would fire off an e-mail to Douglas. He would reply, often within minutes, whether in London or Santa Barbara, or some hotel room anywhere in the world. Unlike most staffers of professional help lines, Douglas understood exactly my problem, knew exactly why it was troubling me, and always had the solution ready, lucidly and amusingly explained. Our frequent e-mail exchanges brimmed with literary and scientific jokes and affectionately sardonic little asides. His technophilia shone through, but so did his rich sense of the absurd. The whole world was one big Monty Python sketch, and the follies of humanity are as comic in the world's silicon valleys as anywhere else.

He laughed at himself with equal good humour. At, for example, his epic bouts of writer's block ("I love deadlines. I love the whooshing noise they make as they go by") when, according to legend, his publisher and book agent would literally lock him in a hotel room, with no telephone, and nothing to do but write, releasing him only for supervised walks. If his enthusiasm ran away with him and he advanced a biological theory too eccentric for my professional scepticism to let pass, his mien at my dismissal of it would always be more humorously self-mocking than genuinely crestfallen. And he would have another go.

He laughed at his own jokes, which good comedians are supposed not to, but he did it with such charm that the jokes became even funnier. He was gently able to poke fun without wounding, and it would be aimed not at individuals but at their absurd ideas. To illustrate the vain conceit that the universe must be somehow pre-ordained for us, because we are so well-suited to live in it, he mimed a wonderfully funny imitation of a puddle of water, fitting itself snugly into a depression in the ground, the depression uncannily being exactly the same shape as the puddle. Or there's this parable, which he told with huge enjoyment, whose moral leaps out with no further explanation. A man didn't understand how televisions work, and was convinced that there must be lots of little men inside the box. manipulating images at high speed. An engineer explained to him about high frequency modulations of the electromagnetic spectrum, about transmitters and receivers, about amplifiers and cathode ray tubes, about scan lines moving across and down a phosphorescent screen. The man listened to the engineer with careful attention, nodding his head at every step of the argument. At the end he pronounced himself satisfied. He really did now understand how televisions work. "But I expect there are just a few little men in there, aren't there?"

Science has lost a friend, literature has lost a luminary, the mountain gorilla and the black rhino have lost a gallant defender (he once climbed Kilimanjaro in a rhino suit to raise money to fight the cretinous trade in rhino horn), Apple Computer has lost its most eloquent apologist. And I have lost an irreplaceable intellectual companion and one of the kindest and funniest men I ever met. I officially received a happy piece of news yesterday, which would have delighted him. I wasn't allowed to tell anyone during the weeks I have secretly known about it, and now that I am allowed to it is too late.

The sun is shining, life must go on, seize the day and all those clichés. We shall plant a tree this very day: a Douglas Fir, tall, upright, evergreen. It is the wrong time of year, but we'll give it our best shot. Off to the arboretum.

Home Christine DeBlase-Ballstadt

THE REALITY CLUB

The Value of Memes:
A Powerful Paradigm or a Poor Metaphor?

Mike Godwin and Jaron Lanier debate the value of memes following Science, Delusion and the Appetite for Wonder, a talk by Richard Dawkins

From: Mike Godwin
Date 12-20-96

Dawkins's powerfully explanatory notion of memes seemed to me at first to have almost casually tossed off in a larger discussion of the dynamics of genetic evolution. Only later did I realize he'd given us a paradigm for understanding how ideas work in cultures, in mass media, and in the growth of knowledge.

It's also a paradigm that gives free-speech advocates some serious social questions to think about. Dawkins's concept of the meme -- that discrete thought that propagates itself, sometimes virulently, through minds and cultures -- forces us to abandon any defense of free speech based on the principle that "words can never hurt you." (Hint: they can hurt you.) Instead, we must defend freedom of expression even though it sometimes allows the spread of *harmful* ideas, because freedom is the only environment that consistently promotes the discovery or creation of the *beneficial* ones.

Together with Karl Popper and Gregory Bateson, whose thinking complements his, Dawkins has done much to shape how I think about the world. He's one scientist who reminds us why we used to call scientists "natural philosophers."

From: Jaron Lanier
To: Mike Godwin
Date: 12-20-96

Hey there Mike,

I just debated Richard Dawkins (it'll appear in *Psychology Today*, of all places). I'm no fan of memes, though I like Richard, and enjoy other aspects of his thinking. Here's a small part of an article I'm working on that concerns memes and many other ways that evolution is applied outside of genetics.

All the best,

Jaron

Spare me your memes

Biological evolution is a theory that explains the remarkable, creative long term effects of massive numbers of untimely (pre-reproductive) deaths, but it is somewhat immune to variations in the sources of genetic variation from which death culls. The current controversies between scientists studying evolution underline this point. Variation might take place without boundaries or favor, as Dawkins seems to suggest, or might be subject to mathematically predetermined paths, as biologists like Kaufman and Goodwin have proposed. In either case, evolution proceeds, through the mechanism of violence. That the theory of evolution can survive these unresolved controversies shows that it is really the culling and not the sowing that is the key mechanism.

The relative indifference of evolution to the source of variation makes it a poor metaphor for understanding creativity that takes place under the protection of civilization. That is one reason why the idea of the "meme" is misleading. The meme concept, first proposed by Richard Dawkins, is sometimes used to explain how ideas change, but also sometimes as an ideal for how ideas should change. Dennett, in "Darwin's Dangerous Idea" speaks of wishing to extinguish a meme that had infected the physicist Roger Penrose as if it were a freakish individual that should be subject to a eugenics campaign. If it weren't for the romance of evolution, "Memes" would just be a fancy way of pointing out that non-rigorous ideas are often subject to a popularity contest. One danger, however, in the meme idea is an equation of creativity with mental eugenics.

There are so many other things wrong with memes that it's hard to list them succinctly. Equating ideas and genes revives all the worst old wrong ideas about genetics. Ideas do everything genes can't. They can change and effect each other without any concern for species boundaries. They can pass along traits acquired during their "lifespans"- they don't have to wait for some sub-strata of genetic material to be selected for. The long-resolved struggle against these mistaken ideas about genes has been irritated into existence again by a stupid metaphor. It is as if Darwin had never existed.

The notion of memes is an affront to the idea that some ideas can be better than others. Ideas can be rigorous, so the notion of improvement has meaning. Genes, on the other hand, don't improve; they just adapt to local circumstance. And that adaptation is entirely non-intentional and so slow that we learn about it largely from fossils. Many kinds of ideas, on the other hand, can be definitively improved, and this can be done methodically and cumulatively, leading to exponential rates of change. People used to believe God thought the world into existence in just this way, in six days. Darwin's central insight was that genes are not like ideas.

Within civilization, nonetheless, are found pseudo-evolutionary processes, like business and the academic career track, in which competition is harnessed to produce excellence. These should not be understood to be true examples of evolution, though, because the genes of the losers are still passed on without diminution. Even their "memes' are passed on, for those who insist on subscribing to the concept. That is what defines a civilization. If civilization worked like evolution, it would be perfectly ordinary to burn library books that had not been read for a long time. In the real world, when libraries burn, civilizations crumble. Marxism provides a recent example.

Ideas are only like memes at the moment when they are extinguished, as happened in the library at Alexandria, or, as might have happened if had he been successful, in Hitler's bonfires.

From: Mike Godwin
To: Jaron Lanier
Date: 12-20-96

Jaron,

As you might expect, I disagree with a number of your arguments. Rather than express my disagreements in great detail, I'll just note some of them here, in a way that perhaps will help you as you further refine your side of the argument. Or perhaps not. It's late.

Biological evolution is a theory that explains the remarkable, creative long term effects of massive numbers of untimely (pre-reproductive) deaths, but it is somewhat immune to variations in the sources of genetic variation from which death culls.

If I understand you correctly here, you're saying that the power of evolutionary theory does not depend on any particular theory as to the source of variation. On that point I agree with you.

So would Karl Popper, I think, were he here to respond to your comment. Popper says something very similar about scientific theories--which might also be called (very loosely) "scientific memes"--in his book CONJECTURES AND REFUTATIONS and elsewhere. In his explanation of the growth of scientific knowledge Popper expressly notes that the *origin* of a theory is irrelevant -- what matters instead is its testability (aka "falsifiability"), which is the indicator of its potential to give us greater knowledge about the world . For example, Kekule's hypothesis about the ringed structure of the benzene molecule originated from a *dream* about a snake eating its tail. But this fact tells us nothing about the value of the the theory, which can only be established empirically.

Thus, dreams, which are arguably the most unstructured and disorded thinking that we ever do, nevertheless can be a source of "variation" as to hypotheses, and ultimately a guidepoint to greater knowledge. Yet even if psychologists were to disagree violently about the relative importance of dreams as a a source of "variation"(read "new ideas), it would not follow from this disagreement that variation itself is relatively unimportant to the growth of knowledge and culture.

Variation might take place without boundaries or favor, as Dawkins seems to suggest, or might be subject to mathematically predetermined paths, as biologists like Kaufman and Goodwin have proposed. In either case, evolution proceeds, through the mechanism of violence. That the theory of evolution can survive these unresolved controversies shows that it is really the culling and not the sowing that is the key mechanism.

I do not believe you have established a syllogism here. I don't see how the robustness of evolutionary theory in the absence of consensus about the sources of genetic variation entails your conclusion that "culling" is more important that "sowing." Both are necessary conditions for Darwin's "origin of species." In fact, Darwin expressly acknowledged that variation was a necessary part of his theory, even though he could articulate no theory as to the source of that variation.

The meme concept, first proposed by Richard Dawkins, is sometimes used to explain how ideas change, but also sometimes as an ideal for how ideas should change.

I think it's unclear to say that "memes" are a notion about "how ideas change." Better to say that they're a notion about how ideas compete with one another, substitute for one another, etc.. (And if "compete" is too telelogical, substitute the verb "interact.") Remember, Dawkins wants us to consider genes as basic units of evolutionary action..

Dennett, in "Darwin's Dangerous Idea" speaks of wishing to extinguish a meme that had infected the physicist Roger Penrose as if it were a freakish individual that should be subject to a eugenics campaign. If it weren't for the romance of evolution, "Memes" would just be a fancy way of pointing out that non-rigorous ideas are often subject to a popularity contest. One danger, however, in the meme idea is an equation of creativity with mental eugenics.

Without going into detail, let me say merely that, in my own experience, thinking about harmful ideas as "bad memes" has been extremely productive for me.

Equating ideas and genes revives all the worst old wrong ideas about genetics.

I think your use of "equating" unfairly dispenses with some of Dawkins's nuance.

Ideas do everything genes can't. They can change and effect each other without any concern for species boundaries. They can pass along traits acquired during their "lifespans"- they don't have to wait for some sub-strata of genetic material to be selected for. The long-resolved struggle against these mistaken ideas about genes has been irritated into existence again by a stupid metaphor. It is as if Darwin had never existed.

It may be that my understanding of genetics has faded since I studied it formally, but much of what you say here about ideas strikes me as self-evidently true about genes as well, .

For one thing, it's not just somatic cells that mutate, but gametic cells as well, and that the latter can pass on their mutations (often but not always deleterious changes). For another, don't ideas require "substrata" as much as genes do?. :Like paper, for example, or air (to transmit sound waves), or a brain?

The notion of memes is an affront to the idea that some ideas can be better than others.

It seems to me to _reinforce_ this very idea. Even we meme-lovers still regard some genes as more harmful than others--harmful either to an organism or to its offspring. Nor does any dispassionate discussion of the dissemination of a meme (a racist meme, say) require that we abandon our opposition that meme. Compare: Does the fact that an epidemiologist can study an epidemic's growth cycle dispassionately entail her abandoning her belief that dying of an infectious disease is a bad thing.

Nothing in Dawkins' metaphor requires us (either as moral actors or as knowledge builders) to think of all ideas as being of equal value *when we are engaged in the process of assessing value*. But the "meme" concept is about understanding the dynamic of the spread of thoughts -- that's where its power as a metaphor lies.,. And the "meme" notion gives us us a way to understand the dynamics of the propagation of ideas that is not clouded by our own assessment of those ideas. In short, thinking about memes allows some of us to see the process more clearly.

Ideas can be rigorous, so the notion of improvement has meaning. Genes, on the other hand, don't improve; they just adapt to local circumstance.

I believe this is both incorrect and a category mistake. Strictly speaking, genes *can* improve (the rare beneficial mutation, for example), and it is not genes but _genotypes_ that adapt.

And that adaptation is entirely non-intentional and so slow that we learn about it largely from fossils.

No problem with your "non-intentional" here, but any bacteriologist, I imagine, can give you what amount to eye-witness accounts of evolutionary adaptation in action. That's one of the nice things about studying the genetics of organisms with short life cycles.

Many kinds of ideas, on the other hand, can be definitively improved, and this can be done methodically and cumulatively, leading to exponential rates of change. People used to believe God thought the world into existence in just this way, in six days. Darwin's central insight was that genes are not like ideas.

I don't recall his saying this. I do recall his recognition that variation is a prerequisite for natural selection. Which to me entails the conclusion that genes are not invariant after all.

Within civilization, nonetheless, are found pseudo-evolutionary processes, like business and the academic career track, in which competition is harnessed to produce excellence.

One can sidestep the road to social Darwinism and still believe that if "pseudo-evolutionary processes" quack just like evolutionary ones, waddle like them, swim and fly like them, why, then we can duck the use of "pseudo." altogether.

These should not be understood to be true examples of evolution, though, because the genes of the losers are still passed on without diminution.

Jaron, I'm not sure I understand your point here, since each of us -- self-evidently the product of our forebears' survival to repductive age -- nevertheless carries in his or her genotype lots of "loser" genes. Unless an allele is lethal to the organism prior to the organism's self-reproduction, the Hardy-Weinberg paradigm more or less still applies, and gene frequencies -- even for ultimately harmful genes! -- in a large population don't change much. (A study of sickle-cell anemia is instructive on this point.)

Commonly it's at the phenotype level that we decide which individuals are "losers" in a particular evolutinary context. -- other individuals who carry the same undesirable allele may well qualify as "winners" in Darwinian terms (they last long enough to reproduce) because their overall phenotype neutralized or minimized the :"loser" effect of that allele. Me, I take Dawkins's argument in THE SELFISH GENE to be in part about transcending this phenotype-centric :"winner/loser" perspect.ive.

I agree of course that one must not *glibly equate* genes and memes. While I still like the notion, I also concede there are countless ways in which this metaphor falls short in representing reality,. Yet isn't this a trivial criticism, given that *all* metaphors -- being comparisons of things that are alike yet also different -- are :necessarily "false" to some degree?.

This irrreducible falsehood of metaphors shouldn't bother us much -- metaphors are meant to be used as tools, not as truths.. And if the tool doesn't work for you, you can abandon it without concluding that it doesn't work for anyone else, either.

Even their "memes' are passed on, for those who insist on subscribing to the concept. That is what defines a civilization. If civilization worked like evolution, it would be perfectly ordinary to burn library books that had not been read for a long time.

As Nicholson Baker has documented, this is in fact perfectly ordinary.

In the real world, when libraries burn, civilizations crumble.

If only this were true. Then book-burning civilizations would invariably die with greater frequency than book-loving ones. But so far as I can tell, all civilizations, including the most literate ones we know of, end up dying, regardless of how nicely they treat their books.

--Mike

From: Jaron Lanier
To: Mike Godwin
Date: 12-20-96

Hello there again,

We do agree on plenty of things. I love Popper's insights on scientific method as much as you do. Alas, no one has yet done such clear work as Popper's to help us choose our metaphors. In examining my criteria for them, and why memes annoy me so, I can propose a starting place: A metaphor ought to inform more than it confuses. Furthermore, it shouldn't unwittingly undermine other notions that one wishes to keep in one's head.

I originally started to dislike memes when I heard students talking about real genes in Lamarkian terms. It turns out they had worked backwards from memes, assuming that ideas must be a reasonable metaphor for genetics in some way. I had to set them straight on that. That set me to wondering if the metaphor worked any better in the forward direction. Since it's very very hard to falsify ideas about ideas, we have to be extra careful about our metaphors for them.

And the "meme" notion gives us us a way to understand the dynamics of the propagation of ideas that is not clouded by our own assessment of those ideas. In short, thinking about memes allows some of us to see the process more clearly.

This I cannot accept. You're making a claim here that you're seeing a process that actually happens, and that you can see it more clearly with the metaphor in mind. First, I worry about the notion of someone becoming a dispassionate observer of ideas, without assessing them. I'm not sure that's possible, and that's a primary problem with the meme metaphor. Can you identify an idea by superficial features, like you can identify an organism? Is it possible to identify an idea without internalizing it? The example I cited in Dennett is not the only one I've seen in which the meme metaphor serves as a tool to help the bearer become somewhat cynical and distanced from the ideas of others.

But I also wonder what process the metaphor of memes can help you observe. Where is the genetic material for an idea?

For another, don't ideas require "substrata" as much as genes do?. :Like paper, for example, or air (to transmit sound waves), or a brain?

You suggest paper and air, but those aren't linked to specific ideas in the way that a particular set of genes are linked to a particular organism. Maybe the metaphor could be lined up in different ways; to the genotype, or wherever, or maybe the idea is like the gene and a behavioral action is like an organism. I've tried to find a way to make the metaphor work! No matter how I try, I can't find a reducible sub-strata in the life of ideas to hang on it. If the meme metaphor informs, it should be possible to name this sub-strata. Can you name it?

Ideas can be rigorous, so the notion of improvement has meaning. Genes, on the other hand, don't improve; they just adapt to local circumstance.

*I believe this is both incorrect and a category mistake. Strictly speaking, genes *can* improve (the rare beneficial mutation, for example)*

In this case I think you are being confused by putting the meme metaphor into reverse gear, like my Lamarkian students. Surely adaptation is only local, while a mathematical theorem is global. A scientific idea, once falsified, is permanently falsified, while a vanished genetic feature might someday reappear if local circumstances change to once again favor it.

And that adaptation is entirely non-intentional and so slow that we learn about it largely from fossils.

No problem with your "non-intentional" here, but any bacteriologist, I imagine, can give you what amount to eye-witness accounts of evolutionary adaptation in action. That's one of the nice things about studying the genetics of organisms with short life cycles.

You're right on this point. What I meant to say is that the genetic rate of change is far slower than the pace of events in the life of an organism. If the meme metaphor informs, once the "genetic" sub-strata has been named, it ought to change very slowly, relative to the pace of discourse. Or if the metaphor should be lined up differently, and the ideas are the genes, there ought to be a faster moving "organism" equivalent that speeds past our ideas.

Evolution is an evil thing. All your genetic features are the result of the pre-reproductive deaths of your would-be ancestors. They were killed in cold blood by your real ancestors, or by micro-organisms, or by cold or hunger. Your features weren't decided by a nice process. If we really want to understand human discourse by making a metaphor with the heart of cruelty, we ought to have a good reason.

I'm not saying the meme metaphor never works at all. When the last copy of a book concerning non-rigorous ideas is destroyed, I think the metaphor might start to work a bit. You could say the book is like genetic material, slower moving than discourse, with discourse being the organism, and that future discourse on related non-rigorous ideas is shaped a bit by the book's absence. While this does happen, the meme metaphor is most popular in the sciences, where it doesn't fit.

For what it's worth, when I presented my arguments to Dawkins, he agreed with them, and said he thought "memes" had been taken too far. You can read what he says about this in his own words in the Psych Today piece, when it comes out.

All the best,

Jaron

From: [Mike Godwin]()
To: [Jaron Lanier]()
Date: 12-20-96

In examining my criteria for them, and why memes annoy me so, I can propose a starting place: A metaphor ought to inform more than it confuses.

Well, perhaps it says something that I disagree with your "starting place" premise. I'm not sure I can say with precision what it is that metaphors do when they aid in understanding, but I don't think "inform" is the right verb. As I said previously, metaphors are tools, not truths. Kind of like what (as I recall) Wittgenstein said the Tractatus should be considered as -- a sort of ladder to the next level that you can throw away once you're up there.

I originally started to dislike memes when I heard students talking about real genes in Lamarkian terms.

If undergraduate misuse of newly acquired notions is all it takes to generate your initial dislike of those notions, I begin to shudder at the implications. (This is a joke.)

Since it's very very hard to falsify ideas about ideas, we have to be extra careful about our metaphors for them.

I'm inclined to say that Dawkin's "meme" notion is simply a metaphor and not a scientific theory. A very powerful metaphor, true, and perhaps even a harmful one. But not something whose unfalsifiability I'd normally worry much about.

And the "meme" notion gives us us a way to understand the dynamics of the propagation of ideas that is not clouded by our own assessment of those ideas. In short, thinking about memes allows some of us to see the process more clearly.

This I cannot accept. You're making a claim here that you're seeing a process that actually happens, and that you can see it more clearly with the metaphor in mind.

The problem is less my proposition, I think than it is my poor usage. Rather than "see the process more clearly" (a phrase that connotes actual observation), I should have written something like "think about the process more clearly."

You may still disagree with the amended claim, but I don't mean for it to be taken as a claim about observations.

First, I worry about the notion of someone becoming a dispassionate observer of ideas, without assessing them.

I believe this is a false dichotomy, since (in my view) one can be a *passionate* observer of ideas (and of other human creations) without imposing a value system upon them. Some of my anthropologist friends, for example, seem to me to be doing just this.

Can you identify an idea by superficial features, like you can identify an organism?

I'm not sure what you're getting at with "superficial" here, but I do think ideas can be classified by clearly discernable features. For example, I believe this is what Popper does with his science/nonscience demarcation criterion.

Is it possible to identify an idea without internalizing it?

I think so. For example, I believe I can identify a Marxist proposition without adopting it.

You suggest paper and air, but those aren't linked to specific ideas in the way that a particular set of genes are linked to a particular organism.

When you used the word "substrate," I found myself thinking of nucleic acids, which, of course are no more specific to a particular gene than paper is specific to a particular idea. I'm still not sure I follow your reasoning here.

*I believe this is both incorrect and a category mistake. Strictly speaking, genes *can* improve (the rare beneficial mutation, for example)*

In this case I think you are being confused by putting the meme metaphor into reverse gear, like my Lamarkian students. Surely adaptation is only local, while a mathematical theorem is global.

Actually, your response suggests a rather different confusion. I don't believe "local" and "global" are terms that represent objective reality.

Popper might have said that a mathematical theorem actually *is* "local" -- it is located in what Popper calls World 3 (the shared domain of human ideas) and it is *not* located under under my bed.

I don't think your local/global distinction is helpful, but you may be reaching for something like the a priori/a posteriori distinction. In any case, once again I have trouble following you.

A scientific idea, once falsified, is permanently falsified, while a vanished genetic feature might someday reappear if local circumstances change to once again favor it.

Popper would say that falsified scientific theories remain in World 3. (They're just reshelved in the "falsified" section.)

I was taught that vanished genetic features *never* simply reappear. E.g., the mammalian species that returns to the sea does not grow scales, even though its long-ago forebears may have had them. Instead, it develops analogous structures or perhaps even arrives at a wholly different solution to the adaptation problem.

You're right on this point. What I meant to say is that the genetic rate of change is far slower than the pace of events in the life of an organism.

This is absolutely right, IMHO, and, incidentally, one of the implications of the Hardy Weinberg equation (or so it seems to me).

If the meme metaphor informs....

Again, I'm uncomfortable with the assumption that metaphors "inform."

Evolution is an evil thing. All your genetic features are the result of the pre-reproductive deaths of your would-be ancestors. They were killed in cold blood by your real ancestors, or by micro-organisms, or by cold or hunger.

Some of them were just too lazy to fuck, Jaron.

I'm not saying the meme metaphor never works at all.

The science of metaphors is never a precise one, I'm thinking.

For what it's worth, when I presented my arguments to Dawkins, he agreed with them, and said he thought "memes" had been taken too far.

Although I disagree with some of what you see, I certainly agree with you and Dawkins (and Danny Hillis) that the notion has been taken too far.

Of course, when my book comes out this spring, you may find that its prolix discussions of memes and media damn me as another culprit in the current meme overload. I'm wincing in anticipation.

Take care.

--Mike

Back to Science, Delusion and the Appetite for Wonder by Richard Dawkins

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No faith in the absurd
Richard Dawkins
Times Education Supplement (London) 23/02/2001, page 17

There is something exceedingly odd about the idea of sectarian religious schools. If we hadn't got used to it over the centuries, we'd find it downright bizarre. The Church of England proudly disclaims any intention to convert pupils away from the faith of their parents. But isn't there already something deeply absurd in the presumption that children ought to inherit beliefs from their parents in the first place?

Think of it this way. Many of the subjects we study are controversial. In civil war history, it's Roundheads versus Cavaliers. In cosmology there is the "steady state" school of thought to set against the now dominant "big bang" theory.

In economics, monetarists vie with Keynesians. In literary history "Baconians" and champions of the Earl of Oxford press rival claims to the authorship of the plays normally attributed to Shakespeare.

In my own field of evolutionary biology, neutralists argue with selectionists. Everyone expects that, in a good school, children will be exposed to the different points of view in matters of controversy, and in a very good school they may even be encouraged to develop their own opinions based upon the evidence and strength of the arguments.

Now, just imagine that sectarian schools were set up for the promulgation of rival points of view in each of these controversial subjects. Imagine Keynesian schools playing football against monetarist schools. Keynesian schools preferentially admit the children of Keynesian parents, while reassuring the parents of the minorities (Monetarist or Adam Smithian children) that they would not seek to convert their children to Keynesianism.

It is one thing for parents to have views on the balance of subjects that their children ought to be taught. Some might feel that languages are more important than mathematics, and choose a school that is especially strong in languages. Or vice-versa.

Within a subject like English, parents might prefer a rigorous grounding in grammatical principles over the literary creativity which other parents might prefer. If schools divide along such lines, nobody could reasonably object.

Some variety of choice would seem positively healthy. But religious schools are divided over what children are taught to believe as facts about the universe, life and existence.

The situation exactly parallels my Keynesian/ monetarist analogy, which was drawn up to be obviously absurd. Who will deny that the existence of religious schools, dispassionately seen, is just as absurd? But it is worse than absurd.

It can be deeply damaging, even lethally divisive. Why do people in Northern Ireland kill each other? It is fashionable to say that the sectarian feuds are not about religion. The deep divides in that province are not religious, they are cultural, historical, economic.

Well, no doubt they are, in the sense that Protestant gunmen or Catholic pub bombers are not directly debating the Transubstantiation, the Assumption, or the Trinity. There is a "them-against-us" mentality burned deep into both sides of the Northern Ireland psyche, and we can all agree that it is not directly related to theological disagreements.

But how does each individual know which side he is on? How does he decide whether the victim of his violence is one of "them" or one of "us"?

He knows because of centuries of historical division. And the basis of that division, generation after generation, is to a large extent sectarian schooling.

If Protestant and Catholic children ceased to be segregated throughout their schooldays, the troubles in Northern Ireland would largely disappear - not overnight, but rather precisely in a generation.

But I come back to my main point. The idea that primary schoolchildren could be labelled "Protestant children" or "Catholic children" is as absurd as "Tory children", "Labour children" or "Liberal children" would be.

No sane person would advocate the setting up of sectarian schools for the segregated education of the children of pro-Euro parents on the one hand and anti-Euro parents on the other. How, then, can it be sane to advocate the existence of sectarian religious schools? And who can justify the spending of taxpayers' money on them?

Richard Dawkins is Charles Simonyi Professor of Public Understanding of Science, Oxford

Backlash against church schools drive
Clare Dean
23/02/2001

The eminent scientist Richard Dawkins is leading a growing chorus of criticism of the Government's plan for more religious schools.

Serious doubts about the proposals among academics and even clergymen have been fuelled by the Church of England's huge financial crisis. Critics have also pointed to dwindling congregations and the difficulties church schools are having recruiting headteachers.

Writing in today's TES, Professor Dawkins, author of The Selfish Gene, who holds the chair for the public understanding of science at Oxford University, said no sane person would advocate setting up "sectarian" schools.

"Who can justify spending taxpayers' money on them?" he asks, warning that religious schools "can be deeply damaging and even lethally divisive".

His concerns were echoed by Anthony Grayling, reader in philosophy at Birkbeck College, London, who said: "Given the great harm that religions do ... in the way of conflict, war, persecution and oppression and preventing the growth of science and freedom of thought. I object profoundly to my taxes being used to this end."

Both Tony Blair and Education Secretary David Blunkett are keen supporters of church schools. Mr Blunkett has said that he wants to bottle the secret of their success.

Nearly a quarter of England's most successful secondaries are run by the Church, although inspectors say selection even purely on religious grounds, helps as it means they are likely to attract well-behaved children from stable backgrounds.

Last week's education Green Paper Building on Success confirmed ministers support for the Church. It came just two months after Anglicans announced plans for 100 new secondaries.

The paper paves the way for more schools provided by the churches and other major faith groups. It announced it would give them £42 million towards capital costs and give faith groups the opportunity to manage and run schools in difficulty.

Lord Dearing, who chaired the review by the Church of England of its schools, had been talking to ministers about their plans. "The Green paper shows that the Government is listening and responding to what we have said," he said.

The paper's proposals have been widely welcomed by church leaders but criticised by the National Secular Society and the British Humanist Association (see page 6).

Lord Dearing said: "It is because it is an increasingly secular society that people are saying they want these anchors in their lives.

"If the children aren't coming to us, we must go to them and that means not only through church schools but in community schools."

The move towards more religious schools comes at a time when three-quarters of Anglican dioceses are in the red, according to an investigation by the Church Times.

Earlier this year, a survey for the National Association of Head Teachers found that church schools experience the most problems recruiting heads.

More than a third of Anglican secondaries have to readvertise a head vacancy. More than half of the top posts in Catholic secondaries were readvertised.

Some clergymen have joined Professor Dawkins in attacking the plans. The Rev David Jennings, rector of Burbage and a member of the Leicester diocesan synod said: "I am not sure we need church schools in the society we live in at the moment.

"Churches run the risk in a multicultural and predominately secular society of establishing something that is not entirely real and, at worst, quite divisive."

The Editor
The Independent
London

Sir: Not for the first time, I am represented as more extreme than I really am ("Dawkins leads atheist revolt against 'evil' church schools", and Leading Article, 24 February). Even the view I actually hold -- that the state should not support religious schools and should open no new ones -- goes less far than the Constitution of the most religiose nation in the western world.

In the article to which you were presumably referring, published in the previous day's issue of the Times Educational Supplement (www.tes.co.uk/this_weeks_edition/opinion/story.asp?id=4402) I simply pointed out that, if we hadn't become historically habituated to the idea, we'd find it bizarre to classify small children by their inherited cosmological and ethical opinions.

We'd be aghast at the branding of "Pro-Euro children" or "Neo-Keynesian children", on the basis of their parents' economic opinions. We do not speak of, let alone separately educate, "Tory children" and "Labour children". We presume that children either are too young to know what they think, or if old enough might disagree with their parents. Why, then, do we accept, without a murmur, the existence and separate education of "Catholic children", "Protestant children", "Jewish children" and "Muslim children"?

Of course it is very convenient for the religions that we do. Indeed, it is probably the main reason for their continued existence.

RICHARD DAWKINS
Oxford

Festival della Scienza

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THE REALITY CLUB

The Value of Memes:
A Powerful Paradigm or a Poor Metaphor?

Mike Godwin and Jaron Lanier debate the value of memes following Science, Delusion and the Appetite for Wonder, a talk by Richard Dawkins

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From: Mike Godwin
Date 12-20-96

Dawkins's powerfully explanatory notion of memes seemed to me at first to have almost casually tossed off in a larger discussion of the dynamics of genetic evolution. Only later did I realize he'd given us a paradigm for understanding how ideas work in cultures, in mass media, and in the growth of knowledge.

It's also a paradigm that gives free-speech advocates some serious social questions to think about. Dawkins's concept of the meme -- that discrete thought that propagates itself, sometimes virulently, through minds and cultures -- forces us to abandon any defense of free speech based on the principle that "words can never hurt you." (Hint: they can hurt you.) Instead, we must defend freedom of expression even though it sometimes allows the spread of *harmful* ideas, because freedom is the only environment that consistently promotes the discovery or creation of the *beneficial* ones.

Together with Karl Popper and Gregory Bateson, whose thinking complements his, Dawkins has done much to shape how I think about the world. He's one scientist who reminds us why we used to call scientists "natural philosophers."

From: Jaron Lanier
To: Mike Godwin
Date: 12-20-96

Hey there Mike,

I just debated Richard Dawkins (it'll appear in *Psychology Today*, of all places). I'm no fan of memes, though I like Richard, and enjoy other aspects of his thinking. Here's a small part of an article I'm working on that concerns memes and many other ways that evolution is applied outside of genetics.

All the best,

Jaron

Spare me your memes

Biological evolution is a theory that explains the remarkable, creative long term effects of massive numbers of untimely (pre-reproductive) deaths, but it is somewhat immune to variations in the sources of genetic variation from which death culls. The current controversies between scientists studying evolution underline this point. Variation might take place without boundaries or favor, as Dawkins seems to suggest, or might be subject to mathematically predetermined paths, as biologists like Kaufman and Goodwin have proposed. In either case, evolution proceeds, through the mechanism of violence. That the theory of evolution can survive these unresolved controversies shows that it is really the culling and not the sowing that is the key mechanism.

The relative indifference of evolution to the source of variation makes it a poor metaphor for understanding creativity that takes place under the protection of civilization. That is one reason why the idea of the "meme" is misleading. The meme concept, first proposed by Richard Dawkins, is sometimes used to explain how ideas change, but also sometimes as an ideal for how ideas should change. Dennett, in "Darwin's Dangerous Idea" speaks of wishing to extinguish a meme that had infected the physicist Roger Penrose as if it were a freakish individual that should be subject to a eugenics campaign. If it weren't for the romance of evolution, "Memes" would just be a fancy way of pointing out that non-rigorous ideas are often subject to a popularity contest. One danger, however, in the meme idea is an equation of creativity with mental eugenics.

There are so many other things wrong with memes that it's hard to list them succinctly. Equating ideas and genes revives all the worst old wrong ideas about genetics. Ideas do everything genes can't. They can change and effect each other without any concern for species boundaries. They can pass along traits acquired during their "lifespans"- they don't have to wait for some sub-strata of genetic material to be selected for. The long-resolved struggle against these mistaken ideas about genes has been irritated into existence again by a stupid metaphor. It is as if Darwin had never existed.

The notion of memes is an affront to the idea that some ideas can be better than others. Ideas can be rigorous, so the notion of improvement has meaning. Genes, on the other hand, don't improve; they just adapt to local circumstance. And that adaptation is entirely non-intentional and so slow that we learn about it largely from fossils. Many kinds of ideas, on the other hand, can be definitively improved, and this can be done methodically and cumulatively, leading to exponential rates of change. People used to believe God thought the world into existence in just this way, in six days. Darwin's central insight was that genes are not like ideas.

Within civilization, nonetheless, are found pseudo-evolutionary processes, like business and the academic career track, in which competition is harnessed to produce excellence. These should not be understood to be true examples of evolution, though, because the genes of the losers are still passed on without diminution. Even their "memes' are passed on, for those who insist on subscribing to the concept. That is what defines a civilization. If civilization worked like evolution, it would be perfectly ordinary to burn library books that had not been read for a long time. In the real world, when libraries burn, civilizations crumble. Marxism provides a recent example.

Ideas are only like memes at the moment when they are extinguished, as happened in the library at Alexandria, or, as might have happened if had he been successful, in Hitler's bonfires.

From: Mike Godwin
To: Jaron Lanier
Date: 12-20-96

Jaron,

As you might expect, I disagree with a number of your arguments. Rather than express my disagreements in great detail, I'll just note some of them here, in a way that perhaps will help you as you further refine your side of the argument. Or perhaps not. It's late.

Biological evolution is a theory that explains the remarkable, creative long term effects of massive numbers of untimely (pre-reproductive) deaths, but it is somewhat immune to variations in the sources of genetic variation from which death culls.

If I understand you correctly here, you're saying that the power of evolutionary theory does not depend on any particular theory as to the source of variation. On that point I agree with you.

So would Karl Popper, I think, were he here to respond to your comment. Popper says something very similar about scientific theories--which might also be called (very loosely) "scientific memes"--in his book CONJECTURES AND REFUTATIONS and elsewhere. In his explanation of the growth of scientific knowledge Popper expressly notes that the *origin* of a theory is irrelevant -- what matters instead is its testability (aka "falsifiability"), which is the indicator of its potential to give us greater knowledge about the world . For example, Kekule's hypothesis about the ringed structure of the benzene molecule originated from a *dream* about a snake eating its tail. But this fact tells us nothing about the value of the the theory, which can only be established empirically.

Thus, dreams, which are arguably the most unstructured and disorded thinking that we ever do, nevertheless can be a source of "variation" as to hypotheses, and ultimately a guidepoint to greater knowledge. Yet even if psychologists were to disagree violently about the relative importance of dreams as a a source of "variation"(read "new ideas), it would not follow from this disagreement that variation itself is relatively unimportant to the growth of knowledge and culture.

Variation might take place without boundaries or favor, as Dawkins seems to suggest, or might be subject to mathematically predetermined paths, as biologists like Kaufman and Goodwin have proposed. In either case, evolution proceeds, through the mechanism of violence. That the theory of evolution can survive these unresolved controversies shows that it is really the culling and not the sowing that is the key mechanism.

I do not believe you have established a syllogism here. I don't see how the robustness of evolutionary theory in the absence of consensus about the sources of genetic variation entails your conclusion that "culling" is more important that "sowing." Both are necessary conditions for Darwin's "origin of species." In fact, Darwin expressly acknowledged that variation was a necessary part of his theory, even though he could articulate no theory as to the source of that variation.

The meme concept, first proposed by Richard Dawkins, is sometimes used to explain how ideas change, but also sometimes as an ideal for how ideas should change.

I think it's unclear to say that "memes" are a notion about "how ideas change." Better to say that they're a notion about how ideas compete with one another, substitute for one another, etc.. (And if "compete" is too telelogical, substitute the verb "interact.") Remember, Dawkins wants us to consider genes as basic units of evolutionary action..

Dennett, in "Darwin's Dangerous Idea" speaks of wishing to extinguish a meme that had infected the physicist Roger Penrose as if it were a freakish individual that should be subject to a eugenics campaign. If it weren't for the romance of evolution, "Memes" would just be a fancy way of pointing out that non-rigorous ideas are often subject to a popularity contest. One danger, however, in the meme idea is an equation of creativity with mental eugenics.

Without going into detail, let me say merely that, in my own experience, thinking about harmful ideas as "bad memes" has been extremely productive for me.

Equating ideas and genes revives all the worst old wrong ideas about genetics.

I think your use of "equating" unfairly dispenses with some of Dawkins's nuance.

Ideas do everything genes can't. They can change and effect each other without any concern for species boundaries. They can pass along traits acquired during their "lifespans"- they don't have to wait for some sub-strata of genetic material to be selected for. The long-resolved struggle against these mistaken ideas about genes has been irritated into existence again by a stupid metaphor. It is as if Darwin had never existed.

It may be that my understanding of genetics has faded since I studied it formally, but much of what you say here about ideas strikes me as self-evidently true about genes as well, .

For one thing, it's not just somatic cells that mutate, but gametic cells as well, and that the latter can pass on their mutations (often but not always deleterious changes). For another, don't ideas require "substrata" as much as genes do?. :Like paper, for example, or air (to transmit sound waves), or a brain?

The notion of memes is an affront to the idea that some ideas can be better than others.

It seems to me to _reinforce_ this very idea. Even we meme-lovers still regard some genes as more harmful than others--harmful either to an organism or to its offspring. Nor does any dispassionate discussion of the dissemination of a meme (a racist meme, say) require that we abandon our opposition that meme. Compare: Does the fact that an epidemiologist can study an epidemic's growth cycle dispassionately entail her abandoning her belief that dying of an infectious disease is a bad thing.

Nothing in Dawkins' metaphor requires us (either as moral actors or as knowledge builders) to think of all ideas as being of equal value *when we are engaged in the process of assessing value*. But the "meme" concept is about understanding the dynamic of the spread of thoughts -- that's where its power as a metaphor lies.,. And the "meme" notion gives us us a way to understand the dynamics of the propagation of ideas that is not clouded by our own assessment of those ideas. In short, thinking about memes allows some of us to see the process more clearly.

Ideas can be rigorous, so the notion of improvement has meaning. Genes, on the other hand, don't improve; they just adapt to local circumstance.

I believe this is both incorrect and a category mistake. Strictly speaking, genes *can* improve (the rare beneficial mutation, for example), and it is not genes but _genotypes_ that adapt.

And that adaptation is entirely non-intentional and so slow that we learn about it largely from fossils.

No problem with your "non-intentional" here, but any bacteriologist, I imagine, can give you what amount to eye-witness accounts of evolutionary adaptation in action. That's one of the nice things about studying the genetics of organisms with short life cycles.

Many kinds of ideas, on the other hand, can be definitively improved, and this can be done methodically and cumulatively, leading to exponential rates of change. People used to believe God thought the world into existence in just this way, in six days. Darwin's central insight was that genes are not like ideas.

I don't recall his saying this. I do recall his recognition that variation is a prerequisite for natural selection. Which to me entails the conclusion that genes are not invariant after all.

Within civilization, nonetheless, are found pseudo-evolutionary processes, like business and the academic career track, in which competition is harnessed to produce excellence.

One can sidestep the road to social Darwinism and still believe that if "pseudo-evolutionary processes" quack just like evolutionary ones, waddle like them, swim and fly like them, why, then we can duck the use of "pseudo." altogether.

These should not be understood to be true examples of evolution, though, because the genes of the losers are still passed on without diminution.

Jaron, I'm not sure I understand your point here, since each of us -- self-evidently the product of our forebears' survival to repductive age -- nevertheless carries in his or her genotype lots of "loser" genes. Unless an allele is lethal to the organism prior to the organism's self-reproduction, the Hardy-Weinberg paradigm more or less still applies, and gene frequencies -- even for ultimately harmful genes! -- in a large population don't change much. (A study of sickle-cell anemia is instructive on this point.)

Commonly it's at the phenotype level that we decide which individuals are "losers" in a particular evolutinary context. -- other individuals who carry the same undesirable allele may well qualify as "winners" in Darwinian terms (they last long enough to reproduce) because their overall phenotype neutralized or minimized the :"loser" effect of that allele. Me, I take Dawkins's argument in THE SELFISH GENE to be in part about transcending this phenotype-centric :"winner/loser" perspect.ive.

I agree of course that one must not *glibly equate* genes and memes. While I still like the notion, I also concede there are countless ways in which this metaphor falls short in representing reality,. Yet isn't this a trivial criticism, given that *all* metaphors -- being comparisons of things that are alike yet also different -- are :necessarily "false" to some degree?.

This irrreducible falsehood of metaphors shouldn't bother us much -- metaphors are meant to be used as tools, not as truths.. And if the tool doesn't work for you, you can abandon it without concluding that it doesn't work for anyone else, either.

Even their "memes' are passed on, for those who insist on subscribing to the concept. That is what defines a civilization. If civilization worked like evolution, it would be perfectly ordinary to burn library books that had not been read for a long time.

As Nicholson Baker has documented, this is in fact perfectly ordinary.

In the real world, when libraries burn, civilizations crumble.

If only this were true. Then book-burning civilizations would invariably die with greater frequency than book-loving ones. But so far as I can tell, all civilizations, including the most literate ones we know of, end up dying, regardless of how nicely they treat their books.

--Mike

From: Jaron Lanier
To: Mike Godwin
Date: 12-20-96

Hello there again,

We do agree on plenty of things. I love Popper's insights on scientific method as much as you do. Alas, no one has yet done such clear work as Popper's to help us choose our metaphors. In examining my criteria for them, and why memes annoy me so, I can propose a starting place: A metaphor ought to inform more than it confuses. Furthermore, it shouldn't unwittingly undermine other notions that one wishes to keep in one's head.

I originally started to dislike memes when I heard students talking about real genes in Lamarkian terms. It turns out they had worked backwards from memes, assuming that ideas must be a reasonable metaphor for genetics in some way. I had to set them straight on that. That set me to wondering if the metaphor worked any better in the forward direction. Since it's very very hard to falsify ideas about ideas, we have to be extra careful about our metaphors for them.

And the "meme" notion gives us us a way to understand the dynamics of the propagation of ideas that is not clouded by our own assessment of those ideas. In short, thinking about memes allows some of us to see the process more clearly.

This I cannot accept. You're making a claim here that you're seeing a process that actually happens, and that you can see it more clearly with the metaphor in mind. First, I worry about the notion of someone becoming a dispassionate observer of ideas, without assessing them. I'm not sure that's possible, and that's a primary problem with the meme metaphor. Can you identify an idea by superficial features, like you can identify an organism? Is it possible to identify an idea without internalizing it? The example I cited in Dennett is not the only one I've seen in which the meme metaphor serves as a tool to help the bearer become somewhat cynical and distanced from the ideas of others.

But I also wonder what process the metaphor of memes can help you observe. Where is the genetic material for an idea?

For another, don't ideas require "substrata" as much as genes do?. :Like paper, for example, or air (to transmit sound waves), or a brain?

You suggest paper and air, but those aren't linked to specific ideas in the way that a particular set of genes are linked to a particular organism. Maybe the metaphor could be lined up in different ways; to the genotype, or wherever, or maybe the idea is like the gene and a behavioral action is like an organism. I've tried to find a way to make the metaphor work! No matter how I try, I can't find a reducible sub-strata in the life of ideas to hang on it. If the meme metaphor informs, it should be possible to name this sub-strata. Can you name it?

Ideas can be rigorous, so the notion of improvement has meaning. Genes, on the other hand, don't improve; they just adapt to local circumstance.

*I believe this is both incorrect and a category mistake. Strictly speaking, genes *can* improve (the rare beneficial mutation, for example)*

In this case I think you are being confused by putting the meme metaphor into reverse gear, like my Lamarkian students. Surely adaptation is only local, while a mathematical theorem is global. A scientific idea, once falsified, is permanently falsified, while a vanished genetic feature might someday reappear if local circumstances change to once again favor it.

And that adaptation is entirely non-intentional and so slow that we learn about it largely from fossils.

No problem with your "non-intentional" here, but any bacteriologist, I imagine, can give you what amount to eye-witness accounts of evolutionary adaptation in action. That's one of the nice things about studying the genetics of organisms with short life cycles.

You're right on this point. What I meant to say is that the genetic rate of change is far slower than the pace of events in the life of an organism. If the meme metaphor informs, once the "genetic" sub-strata has been named, it ought to change very slowly, relative to the pace of discourse. Or if the metaphor should be lined up differently, and the ideas are the genes, there ought to be a faster moving "organism" equivalent that speeds past our ideas.

Evolution is an evil thing. All your genetic features are the result of the pre-reproductive deaths of your would-be ancestors. They were killed in cold blood by your real ancestors, or by micro-organisms, or by cold or hunger. Your features weren't decided by a nice process. If we really want to understand human discourse by making a metaphor with the heart of cruelty, we ought to have a good reason.

I'm not saying the meme metaphor never works at all. When the last copy of a book concerning non-rigorous ideas is destroyed, I think the metaphor might start to work a bit. You could say the book is like genetic material, slower moving than discourse, with discourse being the organism, and that future discourse on related non-rigorous ideas is shaped a bit by the book's absence. While this does happen, the meme metaphor is most popular in the sciences, where it doesn't fit.

For what it's worth, when I presented my arguments to Dawkins, he agreed with them, and said he thought "memes" had been taken too far. You can read what he says about this in his own words in the Psych Today piece, when it comes out.

All the best,

Jaron

From: Mike Godwin
To: Jaron Lanier
Date: 12-20-96

In examining my criteria for them, and why memes annoy me so, I can propose a starting place: A metaphor ought to inform more than it confuses.

Well, perhaps it says something that I disagree with your "starting place" premise. I'm not sure I can say with precision what it is that metaphors do when they aid in understanding, but I don't think "inform" is the right verb. As I said previously, metaphors are tools, not truths. Kind of like what (as I recall) Wittgenstein said the Tractatus should be considered as -- a sort of ladder to the next level that you can throw away once you're up there.

I originally started to dislike memes when I heard students talking about real genes in Lamarkian terms.

If undergraduate misuse of newly acquired notions is all it takes to generate your initial dislike of those notions, I begin to shudder at the implications. (This is a joke.)

Since it's very very hard to falsify ideas about ideas, we have to be extra careful about our metaphors for them.

I'm inclined to say that Dawkin's "meme" notion is simply a metaphor and not a scientific theory. A very powerful metaphor, true, and perhaps even a harmful one. But not something whose unfalsifiability I'd normally worry much about.

And the "meme" notion gives us us a way to understand the dynamics of the propagation of ideas that is not clouded by our own assessment of those ideas. In short, thinking about memes allows some of us to see the process more clearly.

This I cannot accept. You're making a claim here that you're seeing a process that actually happens, and that you can see it more clearly with the metaphor in mind.

The problem is less my proposition, I think than it is my poor usage. Rather than "see the process more clearly" (a phrase that connotes actual observation), I should have written something like "think about the process more clearly."

You may still disagree with the amended claim, but I don't mean for it to be taken as a claim about observations.

First, I worry about the notion of someone becoming a dispassionate observer of ideas, without assessing them.

I believe this is a false dichotomy, since (in my view) one can be a *passionate* observer of ideas (and of other human creations) without imposing a value system upon them. Some of my anthropologist friends, for example, seem to me to be doing just this.

Can you identify an idea by superficial features, like you can identify an organism?

I'm not sure what you're getting at with "superficial" here, but I do think ideas can be classified by clearly discernable features. For example, I believe this is what Popper does with his science/nonscience demarcation criterion.

Is it possible to identify an idea without internalizing it?

I think so. For example, I believe I can identify a Marxist proposition without adopting it.

You suggest paper and air, but those aren't linked to specific ideas in the way that a particular set of genes are linked to a particular organism.

When you used the word "substrate," I found myself thinking of nucleic acids, which, of course are no more specific to a particular gene than paper is specific to a particular idea. I'm still not sure I follow your reasoning here.

*I believe this is both incorrect and a category mistake. Strictly speaking, genes *can* improve (the rare beneficial mutation, for example)*

In this case I think you are being confused by putting the meme metaphor into reverse gear, like my Lamarkian students. Surely adaptation is only local, while a mathematical theorem is global.

Actually, your response suggests a rather different confusion. I don't believe "local" and "global" are terms that represent objective reality.

Popper might have said that a mathematical theorem actually *is* "local" -- it is located in what Popper calls World 3 (the shared domain of human ideas) and it is *not* located under under my bed.

I don't think your local/global distinction is helpful, but you may be reaching for something like the a priori/a posteriori distinction. In any case, once again I have trouble following you.

A scientific idea, once falsified, is permanently falsified, while a vanished genetic feature might someday reappear if local circumstances change to once again favor it.

Popper would say that falsified scientific theories remain in World 3. (They're just reshelved in the "falsified" section.)

I was taught that vanished genetic features *never* simply reappear. E.g., the mammalian species that returns to the sea does not grow scales, even though its long-ago forebears may have had them. Instead, it develops analogous structures or perhaps even arrives at a wholly different solution to the adaptation problem.

You're right on this point. What I meant to say is that the genetic rate of change is far slower than the pace of events in the life of an organism.

This is absolutely right, IMHO, and, incidentally, one of the implications of the Hardy Weinberg equation (or so it seems to me).

If the meme metaphor informs....

Again, I'm uncomfortable with the assumption that metaphors "inform."

Evolution is an evil thing. All your genetic features are the result of the pre-reproductive deaths of your would-be ancestors. They were killed in cold blood by your real ancestors, or by micro-organisms, or by cold or hunger.

Some of them were just too lazy to fuck, Jaron.

I'm not saying the meme metaphor never works at all.

The science of metaphors is never a precise one, I'm thinking.

For what it's worth, when I presented my arguments to Dawkins, he agreed with them, and said he thought "memes" had been taken too far.

Although I disagree with some of what you see, I certainly agree with you and Dawkins (and Danny Hillis) that the notion has been taken too far.

Of course, when my book comes out this spring, you may find that its prolix discussions of memes and media damn me as another culprit in the current meme overload. I'm wincing in anticipation.

Take care.

--Mike

Back to Science, Delusion and the Appetite for Wonder by Richard Dawkins

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No faith in the absurd
Richard Dawkins
Times Education Supplement (London) 23/02/2001, page 17

There is something exceedingly odd about the idea of sectarian religious schools. If we hadn't got used to it over the centuries, we'd find it downright bizarre. The Church of England proudly disclaims any intention to convert pupils away from the faith of their parents. But isn't there already something deeply absurd in the presumption that children ought to inherit beliefs from their parents in the first place?

Think of it this way. Many of the subjects we study are controversial. In civil war history, it's Roundheads versus Cavaliers. In cosmology there is the "steady state" school of thought to set against the now dominant "big bang" theory.

In economics, monetarists vie with Keynesians. In literary history "Baconians" and champions of the Earl of Oxford press rival claims to the authorship of the plays normally attributed to Shakespeare.

In my own field of evolutionary biology, neutralists argue with selectionists. Everyone expects that, in a good school, children will be exposed to the different points of view in matters of controversy, and in a very good school they may even be encouraged to develop their own opinions based upon the evidence and strength of the arguments.

Now, just imagine that sectarian schools were set up for the promulgation of rival points of view in each of these controversial subjects. Imagine Keynesian schools playing football against monetarist schools. Keynesian schools preferentially admit the children of Keynesian parents, while reassuring the parents of the minorities (Monetarist or Adam Smithian children) that they would not seek to convert their children to Keynesianism.

It is one thing for parents to have views on the balance of subjects that their children ought to be taught. Some might feel that languages are more important than mathematics, and choose a school that is especially strong in languages. Or vice-versa.

Within a subject like English, parents might prefer a rigorous grounding in grammatical principles over the literary creativity which other parents might prefer. If schools divide along such lines, nobody could reasonably object.

Some variety of choice would seem positively healthy. But religious schools are divided over what children are taught to believe as facts about the universe, life and existence.

The situation exactly parallels my Keynesian/ monetarist analogy, which was drawn up to be obviously absurd. Who will deny that the existence of religious schools, dispassionately seen, is just as absurd? But it is worse than absurd.

It can be deeply damaging, even lethally divisive. Why do people in Northern Ireland kill each other? It is fashionable to say that the sectarian feuds are not about religion. The deep divides in that province are not religious, they are cultural, historical, economic.

Well, no doubt they are, in the sense that Protestant gunmen or Catholic pub bombers are not directly debating the Transubstantiation, the Assumption, or the Trinity. There is a "them-against-us" mentality burned deep into both sides of the Northern Ireland psyche, and we can all agree that it is not directly related to theological disagreements.

But how does each individual know which side he is on? How does he decide whether the victim of his violence is one of "them" or one of "us"?

He knows because of centuries of historical division. And the basis of that division, generation after generation, is to a large extent sectarian schooling.

If Protestant and Catholic children ceased to be segregated throughout their schooldays, the troubles in Northern Ireland would largely disappear - not overnight, but rather precisely in a generation.

But I come back to my main point. The idea that primary schoolchildren could be labelled "Protestant children" or "Catholic children" is as absurd as "Tory children", "Labour children" or "Liberal children" would be.

No sane person would advocate the setting up of sectarian schools for the segregated education of the children of pro-Euro parents on the one hand and anti-Euro parents on the other. How, then, can it be sane to advocate the existence of sectarian religious schools? And who can justify the spending of taxpayers' money on them?

Richard Dawkins is Charles Simonyi Professor of Public Understanding of Science, Oxford

Backlash against church schools drive
Clare Dean
23/02/2001

The eminent scientist Richard Dawkins is leading a growing chorus of criticism of the Government's plan for more religious schools.

Serious doubts about the proposals among academics and even clergymen have been fuelled by the Church of England's huge financial crisis. Critics have also pointed to dwindling congregations and the difficulties church schools are having recruiting headteachers.

Writing in today's TES, Professor Dawkins, author of The Selfish Gene, who holds the chair for the public understanding of science at Oxford University, said no sane person would advocate setting up "sectarian" schools.

"Who can justify spending taxpayers' money on them?" he asks, warning that religious schools "can be deeply damaging and even lethally divisive".

His concerns were echoed by Anthony Grayling, reader in philosophy at Birkbeck College, London, who said: "Given the great harm that religions do ... in the way of conflict, war, persecution and oppression and preventing the growth of science and freedom of thought. I object profoundly to my taxes being used to this end."

Both Tony Blair and Education Secretary David Blunkett are keen supporters of church schools. Mr Blunkett has said that he wants to bottle the secret of their success.

Nearly a quarter of England's most successful secondaries are run by the Church, although inspectors say selection even purely on religious grounds, helps as it means they are likely to attract well-behaved children from stable backgrounds.

Last week's education Green Paper Building on Success confirmed ministers support for the Church. It came just two months after Anglicans announced plans for 100 new secondaries.

The paper paves the way for more schools provided by the churches and other major faith groups. It announced it would give them £42 million towards capital costs and give faith groups the opportunity to manage and run schools in difficulty.

Lord Dearing, who chaired the review by the Church of England of its schools, had been talking to ministers about their plans. "The Green paper shows that the Government is listening and responding to what we have said," he said.

The paper's proposals have been widely welcomed by church leaders but criticised by the National Secular Society and the British Humanist Association (see page 6).

Lord Dearing said: "It is because it is an increasingly secular society that people are saying they want these anchors in their lives.

"If the children aren't coming to us, we must go to them and that means not only through church schools but in community schools."

The move towards more religious schools comes at a time when three-quarters of Anglican dioceses are in the red, according to an investigation by the Church Times.

Earlier this year, a survey for the National Association of Head Teachers found that church schools experience the most problems recruiting heads.

More than a third of Anglican secondaries have to readvertise a head vacancy. More than half of the top posts in Catholic secondaries were readvertised.

Some clergymen have joined Professor Dawkins in attacking the plans. The Rev David Jennings, rector of Burbage and a member of the Leicester diocesan synod said: "I am not sure we need church schools in the society we live in at the moment.

"Churches run the risk in a multicultural and predominately secular society of establishing something that is not entirely real and, at worst, quite divisive."

The Editor
The Independent
London

Sir: Not for the first time, I am represented as more extreme than I really am ("Dawkins leads atheist revolt against 'evil' church schools", and Leading Article, 24 February). Even the view I actually hold -- that the state should not support religious schools and should open no new ones -- goes less far than the Constitution of the most religiose nation in the western world.

In the article to which you were presumably referring, published in the previous day's issue of the Times Educational Supplement (www.tes.co.uk/this_weeks_edition/opinion/story.asp?id=4402) I simply pointed out that, if we hadn't become historically habituated to the idea, we'd find it bizarre to classify small children by their inherited cosmological and ethical opinions.

We'd be aghast at the branding of "Pro-Euro children" or "Neo-Keynesian children", on the basis of their parents' economic opinions. We do not speak of, let alone separately educate, "Tory children" and "Labour children". We presume that children either are too young to know what they think, or if old enough might disagree with their parents. Why, then, do we accept, without a murmur, the existence and separate education of "Catholic children", "Protestant children", "Jewish children" and "Muslim children"?

Of course it is very convenient for the religions that we do. Indeed, it is probably the main reason for their continued existence.

RICHARD DAWKINS
Oxford

Whole Earth Review, Spring 1989 n62 p90(10)

Universal parasitism and the co-evolution of extended phenotypes. (genetic influences reach outside the body) Richard Dawkins.

To understand Dawkins' thesis you'll need to keep the following distinctions

in mind: Phenotype is the observable appearance of an organism, while genotype is the hidden governing constitution. The genotype manifests itself through the physical attributes of the phenotype. An organism that is of a particular genotype is called a genome.

IN MANY RELIGIOUS CULTS AROUND THE world, ancestors are worshipped. And well they may be, for ancestors, not gods, hold the key to understanding why living things are the way that they are. Of all organisms born, the majority die before they come of age. Of the minority that become parents, an even smaller minority will have descendants alive 1,000 years hence. A tiny minority are the only ones that future generations will be able to call ancestors. This minority had what it takes to be successful. Every organism alive can look back at its ancestors and say the following: Not a single one of my ancestors was killed by a predator, or by a virus, or by a misjudged footstep on a precipice, or a mis-timed handhold on a high tree branch, before begetting or bearing at least one child. Not a single one of my ancestors was too unattractive to find at least one copulation partner, or too selfish a parent to nurture at least one child through to adulthood. Thousands of my ancestors' contemporaries failed in all these respects, but not a single, solitary one of my ancestors failed.

Since all organisms alive inherit their genes from their ancestors, rather than from their ancestors' unsuccessful contemporaries, all organisms alive tend to possess successful genes. This is why organisms tend to inherit genes that build a well-designed machine, a machine that behaves as if it is striving to become an ancestor.

The rationale for this view of life can be seen only if we focus attention on the genes themselves (Williams, 1966; Dawkins, 1976). Genes are documentary information handed down, in the form of copies, from generation to generation. But genes are not only archival documents, passed like a family Bible from ancestor to descendant. They also exert a causal influence on each of the bodies in which they successively reside. They influence the development of arms and legs, of eyes and skins, brains and behavior patterns. Those genes that just happen to cause successive bodies to be more likely to die young, or to be unattractive to the opposite sex, or to fail in caring for children, are not the genes that pass through the net of natural selection into future generations of bodies. It follows that the animals that we see tend to be built by good genes: genes that are good at making bodies that, in turn, are good at passing those same genes on to future generations. It further follows that we can regard an individual animal as a machine for passing on the genes that it contains, a "survival machine" as I have put it.

The way that behavioral ecologists normally express this is to say that individual animals behave in such a way as to maximize their reproductive success. More precisely, it is referred to as their inclusive fitness (Hamilton, 1964). This doctrine has become orthodoxy. When a modern behavioral ecologist sees an animal doing behavior pattern A in situation P, his immediate reaction is to ask: "In what way is behavior pattern A good for the animal in situation P?" His colleagues may disagree with the answer he comes up with. Some of them may dispute the premise of the question, accusing him of being too "adaptationist, " perhaps of neglecting a "developmental constraint, or of neglecting the power of neutral drift. But, following my book The Extended Phenotype (1982), I want to raise a very different kind of problem. I suspect that the animal we are watching may be being manipulated by some other animal or plant, perhaps behind the scenes.

The animal we are watching is moving under the power of its own muscles, of course, and its own brain is giving the orders. Since the brain and muscles grew under the influence of the animal's own genes we assume, as good neo-Darwinians, that the brain and muscles are working for the benefit of the animal's own genes. But what if there is some other animal lurking behind the scenes, pulling the puppet strings? Then, instead of asking "In what way is this animal benefiting from its behavior?" we should ask: "Which animal is this behavior benefiting?"

Parasites provide most of the examples we know about so far. Many flukes have a complicated life cycle, involving one or more intermediate hosts, before they finally infect their definitive host. For instance, flukes of the genus Leucochloridium have a snail as their intermediate host. From this they have to pass to a bird, and, in order for this to happen, their snail must be eaten by a bird, or at least the part of the snail containing the fluke. They could just sit back and wait for this to happen, but in fact they take active steps to make it happen. They burrow up into the tentacles of the snail, where they can be seen through the snail's skin, conspicuously pulsating. This makes the tentacles look to a bird like tempting morsels in their own right. Wickler (1985) suggests that they look like insects. Anyway, birds peck them off, and the fluke achieves the next stage in its life cycle.

What is more interesting from our point of view is that the flukes even manage to change the snails' behavior. The snails are normally negatively phototactic: they tend to avoid light, and therefore do not approach the tops of plants on which they feed. Infected snails change their behavior. They become positively phototactic, actively seeking light. This carries them up to the open tops of the plants, and makes them more likely to be seen by birds. Perhaps the fluke achieves this by interfering with the optic nerves of the snail: the eyes are, after all, in the tips of the tentacles into which the flukes have burrowed. From our point of view, it is sufficient that the parasites do change the behavior of the host, in such a way as to benefit the parasite, but not the host. If a behavioral ecologist watched the behavior of the snail, and asked: "In what way does its light-seeking behavior benefit the snail?" he would seek in vain for an answer. The truth is that some other animal, in this case a fluke, is manipulating the snail from behind the scenes. The behavioral ecologist would have done better to ask: "Which animal is this behavior benefiting?"

It is not just behavior that parasites manipulate. There is a protozoan parasite, Nosema, that infects beetle larvae. As far as the beetle larva is concerned, the purpose of its existence is to feed and grow until it is big enough to metamorphose into an adult beetle and reproduce. But the parasite has no interest in its host's reproducing. The parasite simply "wants" its host to go on growing and providing food for more and more of the parasite's descendants. It achieves this by a remarkable feat of biochemical manipulation. The parasites together (presumably they are a clone) succeed in synthesizing the juvenile hormone, or a close chemical analog of it. juvenile hormone is the substance that insects normally synthesize to maintain larval growth and inhibit metamorphosis. Human experimenters have shown that, if you inject an insect larva with juvenile hormone, you can stop it metamorphosing. These Nosema parasites have "discovered" the same thing! They synthesize the juvenile hormone and secrete it into the beetle larva's body. Instead of metamorphosing, the larva continues to grow through as many as six extra larval moults, end- ing up as a giant larva more than twice the normal size.

In the case of the snail's phototaxis, it might have been possible to regard the change as an accidental byproduct, not as a true adaptation by the parasite. In the case of Nosema, it is hardly possible to maintain this. juvenile hormone is not something that protozoa ordinarily have anything to do with. Achieving the feat of synthesizing a specific molecule like a hormone indicates true adaptation by natural selection over many generations.

Once again, the conclusion I want to draw concerns the kind of question that behavioral ecologists should ask. We are tempted to look at a giant beetle larva and ask: "How does this giantism benefit the insect?" Instead, we should ask: "Who is benefiting from the giantism?" The answer, once again, is not the animal itself, but a manipulator hidden behind the scenes.

These examples are all from the point of view of individual organisms. But, as stated at the outset, all adaptation should fundamentally be seen at the genetic level. If the animal we are watching is behaving for the benefit of a manipulator behind the scenes, we must express this at the genetic level. Just as, in normal adaptation, we say that an animal behaves so as to benefit the genes that it contains, so, in the case of these parasites, we must say that the host behaves in such a way as to benefit the parasite's genes. And the reason is the same. just as, normally, an animal's development is influenced by the genes that it contains, so a parasitized beetle larva's development is influenced by the genes of the parasite. The conclusion of the doctrine of the extended phenotype" is that a gene in one animal may have phenotypic expression in the body of another animal. It is this doctrine that I want to persuade you of, and I am doing so largely by talking about parasites.

The snail can be regarded as a vehicle exploited by a fluke. A beetle larva can be regarded as a vehicle exploited by a protozoan parasite. But the selfish gene view of life sees this as just a larger version of the normal relationship of a gene to the body in which it sits. A body is just a gene's vehicle for getting into the next generation, and hence into an indefinite series of future generations. A snail is just a fluke's way of getting into a sheep, and hence of getting its genes into the future.

But why do we assume that the fluke genes work with a kind of group loyalty to one another, while the snail genes oppose them and work with a group loyalty to one another? Many people do not see this as a question that needs an answer at all. They see it as the starting assumption, that the whole of a body works together for the entire reproductive success of all of that body, in other words, for the propagation of all its genes.

But it is more fundamental for genes to work in their own interests. Under what circumstances might we expect genes within one genome to rebel, and not to pull together with one another for the common good? We would expect this if some genes had found a way of breaking out of the ordinary meiotic lottery involved in making gametes [the random division of chromosomes], and succeeded in manipulating their bodies into spreading them some other way. Suppose, for instance, that a gene succeeded in making its bodies sneeze them out, so that they could be breathed in by another body. Such a gene might well share with ordinary genes the same interest in preserving the individual body alive. But it would not share with ordinary genes the same interest in making that body have offspring, via sperm or eggs. This partial divergence of interests will tend to make the sneezed genes behave in a more detrimental, parasitic" manner. Are there any examples of such genes? Well, if there were, by definition we would not call them members of the body's own genome. We might call them virus genes.

The only reason all genes are not rebels like this is that all the genes in one individual organism normally stand to gain from the propagation of the gametes of that organism. Rebelling is difficult, for reasons that in themselves require an explanation, and which have to do with the disciplined fairness of the meiotic lottery. Given that rebelling is difficult because of the way meiosis works, selfish genes can normally actually benefit themselves best by cooperating with others in the same body, in order to promote the reproduction of that body, as a coherent entity.

Briefly, I believe that this amicable state of affairs comes about in the following general way. Genes that can make use of one another's products tend to prosper in one another's presence. This sets up a climate in which genes that cooperate are favored. "Climate" means a climate provided by other genes. From any one gene's point of view, other genes can be regarded as part of the environment, in much the same way as the external temperature and humidity can be regarded as part of the environment. "Cooperate" just means work together, especially work together to make the whole genome behave as a single coherently purposeful unit. This in turn increases the unitariness and coherence of the body, which in turn increases the pressure for the genes to be even more cooperative, and specifically increases the pressure for all the genes to converge upon the same method of leaving the body. So we have a self-sustaining, self-reinforcing evolutionary trend towards large units of phenotypic power. To go back to the example of snails and flukes, we normally think of parasites as weakening their hosts. But there are some cases where, at least at first sight, they strengthen their hosts. Cases have been reported of snails parasitized by flukes having thicker and stronger shells than unparasitized snails. Does this mean that the snails actually derive some benefit from the flukes? In the sense of being better protected, the answer may well be yes, but it will not be a net benefit. When we consider benefits, we must not forget economic costs. It costs calcium and perhaps other resources to make a thick shell. We may be sure that the snail, and not the fluke, is bearing these costs. From the snail's point of view, a shell that is too thin is bad, for the obvious reason that it provides inadequate protection. But a shell that is too thick is also bad, because it consumes resources that could have been spent more profitably elsewhere in the economy of the snail. for instance, in making more eggs. Admittedly a super-thick shell presumably provides even better protection than a normal shell, but if, so to speak, the snails thought it worthwhile for this reason, they would have invested in it anyway! By making them have a thicker shell than they "want, " the flukes are not doing the snails a favor, unless the flukes are, in some way, shouldering the economic cost of the extra thickness. We may be pretty sure that they are not.

Is there any reason for the flukes to "prefer" a thicker shell than the snail does? Yes, I think a plausible case can be made, precisely because the flukes are not shouldering the economic burden. From the snail's point of view, the weighing up of costs and benefits can be thought of as a trade-off between survival and reproduction. A thicker shell means that the snail's own life expectancy is increased, but the economic costs of the thicker shell are felt as reduced reproductive success. Natural selection presumably arrives at an optimum balance.

But from the fluke's point of view the optimum balance looks different. The fluke is also inter- ested in the snail's survival, since its own survival is intimately bound up with the survival of its host (at least for a while). But the fluke has no specific interest in the reproductive success of its host. To be sure, it has a vague interest in the entire species of snails having reproductive success, so that there will be a new generation of snails to parsitize. But it has no specific interest in the reproductive success of its particular host, since the benefits of this to the next generation of flukes would be shared by all its rival flukes. As far as its particular host is concerned, it would be quite happy if that host were castrated. Indeed some parasites, as we know, do castrate their hosts, probably gaining benefits in the increased bodily growth of the host (Baudoin, 1975).

So, as far as snail shell thickness is concerned, there are two optima. The snail's optimum shell is thinner than the fluke's optimum. Switching, now, to gene language and the language of the extended phenotype, the snail phenotype is influenced not only by snail genes but also by fluke genes. These influences, to some extent, tug in opposite directions. The phenotype that we actually observe is probably a compromise between the two influences.

This is a slightly unfamiliar way of looking at life, so I will explain it in another way. Imagine three geneticists all doing research on the genetics of snail shell thickness. All three geneticists, in other words, are studying the same set of varying phenotypes. They differ with respect to the genes that they consider. One of the the three geneticists is a snail scientist. He studies the inheritance of shell thickness in pedigrees of snails. To him, the contribution of flukes to variations in the phenotype is strictly an environmental contribution to the variance. The second geneticist is a fluke geneticist. He studies the inheritance of host shell thickness in pedigrees of flukes. To him, the contribution of snail genes to variation in shell thickness is strictly an environmental contribution! I hope it is clear that both geneticists are practicing perfectly respectable genetics, albeit the fluke geneticist is a little unconventional. Yet each of them is relegating the genes studied by his colleague to the environmental category.

As you may have guessed, the resolution of this apparent paradox is achieved by the third geneticist. The third geneticist is an extended geneticist. He treats the variation in the shell phenotype as being under the joint influence of both snail genes and fluke genes. When you think about it, this is just what geneticists do all the time anyway, when they are studying genes within one genome. Geneticists are entirely accustomed to the idea that several genes influence the same phenotype. They normally think in terms of several genes of the "same" genome, but the whole point I am making is that there is nothing particularly special about the "same" genome. Fluke genes and snail genes can jointly influence the same phenotype, in just the same kind of way as snail genes and snail genes ordinarily interact with one another.

We have again reached our puzzle. Why do we assume that all the snail genes pull together as a team, while all the fluke genes pull together as a different team? The answer is not that there is anything qualitatively different about fluke genes and snail genes, some essence of snailiness or flukiness that pervades the substance of the genes. What, then, is the answer? The answer lies in the fact that the snail genes all share the same method of leaving the present snail body, and the fluke genes do not. The fluke genes in their turn all share the same method of leaving the present snail body, and the snail genes do not.

Why does the method of leaving the body matter so much? It matters because on it depends the series of events, in the future, from which the two sets of genes stand to gain. There is a partial overlap of interests. Both fluke genes and snail genes stand to gain from the snail's succeeding in finding food of the kind that best suits the snail's health. Both stand to gain from the snail's finding shelter from cold and other climatic hazards. Both, to a large extent at least, stand to gain from the snail's continuing to survive, But the two do not overlap in benefiting from the snail's reproducing. Snail genes that make the snail successful in finding a mate will be favored in the snail gene pool. Fluke genes that have the same effect on the snail will not be favored in the fluke gene pool.

In general, parasitologists should pay attention, above all other things, to the extent of overlap between methods of leaving the shared (host) body. Those parasites that put their gametes inside host gametes stand to gain from an almost identical set of future events to their host genes. They can therefore be expected to cooperate with their host as benign parasites or symbionts.

Some bacterial parasites of beetles not only live in the beetle's body. They also use the beetle's eggs as their transport into a new beetle. The genes of such a parasite therefore stand to gain from almost exactly the same set of future circumstances as the genes of their host. The two sets of genes, therefore, would be expected to pull together, for exactly the same reasons as all the genes of one organism pull together. It is irrelevant that some of them happen to be beetle genes while others happen to be bacterial genes. Both sets of genes are interested in the propagation of beetle eggs. Both sets of genes, therefore, are interested in making the beetle bodies successful in all departments of life, in both survival and reproduction. This is not true of the fluke genes and snail genes. The fluke genes care about snail survival, but not about snail reproduction. Therefore the cost/benefit calculations of snail genes and fluke genes come out differently. In the case of transovarial parasites like these bacteria, the cost/benefit calculations of host genes and parasite genes come out the same in all departments of life.

We now can take a radically unfamiliar view of any animal's "own" genes, and why they pull together for the good of all. The reason, quite simply, is that all expect to leave the present body by the same route as each other, by the same sperm or eggs. To be sure, in sexually reproducing organisms, not all genes get into all gametes. Indeed, each gene has only a 50-percent chance of getting into any given gamete. But all have the same statistical chance of getting into each gamete. As long as rogue genes do not cheat, and increase these odds - which some genes, the so-called segregation distorters, actually do (Crow, 1979) - all the genes stand to gain from the same set of events in the future. Fundamentally the reason is that meiosis is largely a fair, unbiased lottery.

This opens the new question of why meiosis is largely a fair, unbiased lottery. This is not a question I will tackle here. For now, I shall just accept that it is, and note what follows from it. The conclusion is that the genes of any one organism pull together for just the same reason as the genes of a transovarially transmitted bacterium pull together with the genes of its host. just as transovarially transmitted parasites are exceedingly "gentle" parasites - indeed not true parasites at all but mutualistic symbionts - so all the genes of a body can be regarded as gentle parasites of that body. The gentler the parasite, the more intimate the mutualism of a symbiotic relationship, and the less obvious it will be to us that it is a parasite at all. The parts will come to merge, until we cease to call the relationship parasitic or symbiotic, and think of the entire partnership as a single body. This is what has happened to mitochondria and other cell organelles, if Lynn Margulis's (1970) symbiotic theory is right. I want to go even further than Margulis, and regard all "normal" nuclear genes as symbiotic in the same kind of way as mitochondrial genes.

Parasites do not have to live inside their hosts. Cuckoos are perfectly good parasites, but they do not live inside their host's body, merely in its nest. They do not exploit the host's physiology directly, but indirectly via its behavior. But the principle is exactly the same, and the doctrine of the extended phenotype applies in the same kind of way.

It is easy to sympathize with the host foster parent when the cuckoo is at the egg stage. The eggs laid by a female of any one race closely resemble the eggs of the host species. The foster parent is fooled, in the same way as any victim of mimicry. We, can sympathize because human egg collectors - for such disreputable creatures were once, I regret to say, common - have frequently been fooled. We find it much harder to sympathize with the foster parent when the cuckoo youngster has grown near to the point of fledging. It seems to us the height of absurdity when we see a picture of a tiny reed warbler, standing on the back of its monstrous foster child in order to reach its huge open gape and drop food into it (Hamilton and Orians, 1965). Surely any fool could see that the nestling cuckoo is not a reed warbler. It is one thing to be fooled by subtle egg mimicry, but who could be fooled by a fake child seven times the size of the real thing? Putting the problem in a less subjective and more Darwinian way, how can natural selection be so efficient in perfecting the egg mimicry of the cuckoo, yet so inefficient in allowing grossly oversized nestlings to survive their foster parents' discrimination?

The problem is lessened by the following consideration. The cost of failure, from the point of view of the foster parent, is less at the egg stage of the cuckoo than at the nestling stage. A reed warbler who succeeds in detecting a cuckoo egg gains an entire breeding season. A reed warbler who succeeds in detecting a nearly fledged cuckoo has little to gain, since the season is nearly over anyway. But, even so, it seems hard to believe that a visual system sharp enough to detect the mimicry of cuckoo eggs could be "stupid" enough to be fooled by a cuckoo fledgling.

Perhaps "fooled" is the wrong word. A human male may be sexually aroused, even physiologically aroused, by a photograph or drawing of a female. Suppose a Martian ethologist observed this phenomenon. Would he say: "How silly to be fooled by this fake woman. Surely anyone can see that she is only a pattern of printing ink on paper, and only about a tenth of natural size. " Men of course are not actually "fooled" by the picture. They do not really think it is a woman. They simply find themselves aroused by it in the same kind of way as they might be by a real woman. Perhaps something like this is true of the cuckoo's foster parent. There are many well-documented observations of adult birds, of many species, flying home with food for their own young, and being diverted by the chance sighting of a gaping cuckoo nestling in another bird's nest. They then feed the cuckoo in the other bird's nest, in apparent preference to their own young in their own nest. Perhaps the cuckoo nestling is, as Oskar Heinroth is reported to have said, a "vice" of its foster parents. He said that the parents behave like "addicts. " Is the colored gape of the young cuckoo like an irresistible drug? Following Dawkins and Krebs (1978) and Krebs and Dawkins (1984), I want to make the general case that animals may manipulate other animals with weapons that we can best understand if we think of metaphors like "drugs" and "hypnosis. Keith Nelson once gave a talk about bird song entitled: "Is bird song music? Well, then, is it language? Well, then, what is it?" I want to make the case that, at least in some cases, it may be akin to hypnotic persuasion, spellbinding oratory, hauntingly irresistible music. The poet Keats wrote, in his Ode to a Nightingale,

My heart aches, and a drowsy numbness pains My sense, as though of hemlock I

had drunk, Or emptied some dull opiate to the drains One minute past, and

Lathe-wards had sunk. What I am suggesting is that nightingale song, cuckoo gapes, and many pheromones perhaps are exerting an influence on their receivers' ner- vous systems which is irresistible in the same kind of way as a drug may be irresistible. Or as the electric currents of a neurophysiologist may be irresistible. A neurophysiologist can implant electrodes in carefully chosen parts of the brain of a cat or a chicken and, by passing current down them, manipulate the behavior of the animal like a puppeteer pulling strings. If the brain is vulnerable to such manipulation, should not natural selection, working on other animals, have perfected the power to manipulate? To be sure, animals cannot literally bore holes in one another's brains, cannot literally pass electric current in. But there are convenient holes already bored: eyes, ears, and noses. They provide ready-made channels into the deep parts of the brain and they are, in some senses, predisposed to be manipulated. A reed warbler's brain already has the predisposition to be attracted to the open gapes of it,,; own young. The young cuckoo has only to tap into this ready-made channel into the brain, and it apparently is not all that difficult to go one better and evolve a supernormal stimulus. Natural selection would surely favor animals that succeed in manipulating the nervous systems of other animals in this kind of way.

The obvious question now stands out. Why do victims of manipulation stand for it? Just as natural selection would favor manipulators who discover and exploit portholes into the brains of their victims, so natural selection will favor those would-be victims who close off those very portholes. How can there be any long-term future in manipulation as a way of life? One possible answer is that there is not any long-term future. It could be that cuckoos can survive only by exploiting evolutionary time lags. Perhaps cuckoos can exploit any one host species for only a few centuries, before the host gene pool accumulates enough genes for resisting manipulation. Then selection in the cuckoo gene pool favors those who start exploiting a new species which is still, evolutionarily speaking, naive about the dangers of being manipulated, There is some direct evidence that this may be at least a part of the truth (N. B. Davies and M. de L. Brooke, in preparation). But I doubt if it is the whole truth. I think we also need to consider the theory of evolutionary arms races, and how they may end (Dawkins and Krebs, 1979).

An evolutionary arms race is a process of co-evolution in which advances on one side are matched by counter-advances on the other, which in turn provoke further advances on the first side, and so on. Arms races are common between predators and prey, and parasites and hosts, and are one of the principal forces driving towards progressive evolution of ever more complex and sophisticated biological armament and instrumentation (Dawkins, 1986). As so far described, there seems no obvious way for an arms race to end. But this is too simple. We have left economics out of the discussion. Arms races do not, in any case, make sense without economic considerations.

There are economic and other costs to each side in each advance in the arms race. For a deer to evolve faster running, for example, it must develop bigger muscles. This means spending more resources on muscle tissue, resources which could have been spent on, say, reproduction. There will be some optimum compromise between amount spent on leg muscles and amount spent on reproduction. Any individual deer that spends less than the optimum will be vulnerable to being eaten. But also, any individual deer that spends more than the optimum will be less reproductively successful than an individual spending the optimum amount. The overspender, to be sure, may live longer as an individual. But it will not pass so many genes on to future generations, so genes for overspending will not increase in the gene pool. If it were not for such economic considerations, all animals would run as fast as cheetahs and would be as clever as humans.

Now, what happens to this optimum if there is an arms race going on? If the predators increase their running speed, there will be a shift in the timum balance within the deer gene pool. Individuals that previously would have been classed as overspenders now propagate more genes than individuals that previously would have been classified as optimal. So the deer population takes a step in the direction of greater average running speed. This in turn changes the optimum in the predator population, and so on.

But now, what if there are asymmetries in the economic calculations on the two sides of the arms race? Two thousand years ago, Aesop noted that the rabbit runs faster than the fox, because the rabbit is running for his life, while the fox is only running for his dinner. The cost of failure in running speed, for the fox, is merely a lost dinner. The cost of failure in running speed, for the rabbit, is a lost life. In the trade-off between spending resources on leg muscles and on reproduction, therefore, the optimum for the fox population could well come out very different from the optimum for the rabbit population.

We can apply this kind of economic thinking to the case of cuckoo nestlings manipulating their foster parents. The cost of failure to a young cuckoo is death. The cost of failure to a foster parent is the loss of part of one breeding season. To put it another way, the cuckoo is descended from a long line of ancestors, every single one of whom has succeeded in manipulating a foster parent. The foster parent is descended from a long line of ancestors, only a proportion of which ever met a cuckoo in their lives, and even that proportion had another chance to reproduce after failing in that one year. Maybe the arms race between cuckoos and reed warblers has ended in a kind of stable compromise.

If there are economic costs to a reed warbler in resisting manipulation by cuckoos, it is even possible that natural selection among reed warblers favors complete capitulation. if cuckoos, for instance, were rare, then any individual reed warbler that was prepared, genetically speaking, to pay the cost of resistance, might actually be less successful than a rival individual that made no attempt whatever to resist cuckoos. Total nondiscrimination could be, for economic reasons, a better policy than costly discrimination, even though nondiscrimination carries the risk of parasitization.

If animals can manipulate other animals, and if the economics of arms races leads to stable equilibria in which the victims of manipulation acquiesce in being manipulated, we once again arrive at the same conclusion as before. When a behavioral ecologist looks at some feature of an animal's behavior, or anatomy, he should not necessarily ask, "How does this feature benefit the animal?" Instead, he should ask, "Which animal is this feature benefiting?" Whereas, before, the hidden manipulator behind the scenes was assumed to be a parasite inside the host's body, with direct access to the host's physiology and biochemistry, we have now extended our view to include manipulators outside the victim's body. The manipulator can even be a long way away, manipulating its victim by sound, or by chemical means.

I can summarize the extended phenotype view of life by contrasting it with two others in the form of diagrams. The two others can conveniently be labeled with the names of the great biologists who advocated them, Lamarck and Weismann. In the Lamarckian view of life (actually Lamark simply adopted a prevailing view of his contemporaries and predecessors, but his name is conveniently used as a label), bodies pass on their attributes to descendant bodies fig. 1). Hence new characteristics acquired during the body's life can be passed on. The Lamarckian view was replaced by the Weismannian view, according to which the germ-lines (we should now say the genes) are passed down the generations, influencing bodies as a side issue. A very important side issue, it has to be hastily said, since the survival or nonsurvival of the genes largely depends upon their effects upon bodies. The extended phenotype view of life (fig. 3) is an extension of the Weismannian view. Indeed, I would maintain that it takes Weismannism to its logical conclusion. There is still an immortal germ-line, and genes still survive or perish by virtue of their phenotypic consequences. But those phenotypic consequences are no longer limited to the body in which the genes are sitting. Genetic influences reach out beyond the body of the individual organism and affect the world outside, both the inanimate world and other living organisms. Coevolution, and the interaction between organisms, is best seen as an interlocking web of extended phenotypes. Literature CITED

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Why don’t animals have wheels?

by Richard Dawkins
Article in The Sunday Times, November 24th 1996

The wheel is the archetypal, proverbial, human invention. We don’t just travel on wheels, it is wheels – forgive me – that make the world go round. Take apart any machine of more than rudimentary complexity and you’ll find wheels. Ship and aeroplane propellors, spinning drills, lathes, potters’ wheels – our technology runs on the wheel and would seize up without it.

The wheel may have been invented in Mesopotamia during the fourth millennium BC. We know it was elusive enough to need inventing, because the New World civilisations stilll lacked it by the time of the Spanish conquest. The alleged exception there – children’s toys – seems so bizarre as to prompt suspicion. Could it be one of those false legends, like eskimos having 50 words for snow, which spreads purely because it is so memorable?

Whenever humans have a good idea, zoologists have grown accustomed to finding it anticipated in the animal kingdom.. Why not the wheel? Bats and dolphins perfected sophisticated echo-ranging systems millions of years before human engineers gave us sonar and radar. Snakes have infra-red heat detectors for sensing prey, long pre-dating the Sidewinder missile. Two groups of fish, one in the New World and one in the Old, have independently developed the electric battery, in some cases delivering currents strong enough to stun a man, in other cases using electric fields to navigate through turbid water. Squids have jet propulsion, enabling them break the surface at 45 m.p.h. and shoot through the air. Mole crickets have the megaphone, digging a double horn in the ground to amplify their already astonishingly loud song. Beavers have the dam, flooding a private lake for their own safe-conduct over water.

Fungi developed the antibiotic (of course, that’s where we get penicillin from). Millions of years before our agricultural revolution, ants planted, weeded and composted their own fungus gardens. Other ants tend and milk their own aphid cattle. Darwinian evolution has perfected the hypodermic needle, the valved pump, the fishing net, the harpoon, the fishing rod, the water pistol, the automatic focus lens, the lightmeter, the thermostat, the hinge, the clock and the calendar. Why not the wheel?

Now, it is possible that the wheel seems so marvellous to us only by contrast with our rather undistinguished legs. Before we had engines driven by fuels (fossilised solar energy), we were easily outpaced by animal legs. No wonder Richard III offered his kingdom for four-footed transportation out of his predicament. We show up poorly against two-legged runners, too, in the form of ostriches and kangaroos. Perhaps most animals wouldn’t benefit from wheels because they can already run so fast on legs. After all, until very recently, all our wheeled vehicles have been pulled by leg power. We developed the wheel, not so as to go faster than a horse, but so as to enable a horse to transport us at its own pace – or a bit less. To a horse, a wheel is something that slows you down.

Here’s another way in which we risk over-rating the wheel. It is dependent for maximum efficiency on a prior invention – the road (or other smooth, hard surface). A car’s powerful engine enables it to beat a horse or a dog or a cheetah on a hard, flat road, or smooth, iron rails. But run the race over wild country or ploughed fields, perhaps with hedges or ditches in the way, and it is a rout: the horse will leave the car wallowing. Size for size, a running spider is surely faster than any wheeled vehicle over any terrain.

Well then, perhaps we should change our question. Why haven’t animals developed the road? There is no great technical difficulty. The road should be childsplay compared with the beaver dam or the bower-bird’s ornamented arena. There are even some digger wasps that tamp soil hard, picking up a stone tool to do so. Presumably the same skills could be used by larger animals to flatten a road.

Now we come to an unexpected problem. Even if roadbuilding is technically feasible, it is a dangerously altruistic activity. If I as an individual build a good road from A to B, you may benefit from the road just as much as I do. Why should this matter? This raises one of the most tantalising and surprising aspects of all Darwinism, the aspect that inspired my first book, The Selfish Gene. Darwinism is a selfish game. Building a road that might help others will be penalised by natural selection. A rival individual benefits from my road just as much as I do, but he does not pay the cost of building.

Darwinian selection will favour road building only if the builder benefits from the road more than his rivals. Selfish parasites, who use your road and don't bother to build their own, will be free to concentrate their energy on outbreeding you, while you slave away on the road. Unless special measures are taken, genetic tendencies towards lazy, selfish exploitation will thrive at the expense of industrious roadbuilding. The upshot will be that no roads get built. With the benefit of foresight, we can see that everybody will be worse off. But natural selection, unlike we humans with our big, recently evolved brains, has no foresight.

What is so special about humans that we have managed to overcome our antisocial instincts and build roads that we all share. We have governments, policed taxation, public works to which we all subscribe whether we like it or not. The man who wrote, "Sir, You are very kind, but I think I'd prefer not to join your Income Tax Scheme", heard again, we may be sure, from the Inland Revenue. Unfortunately, no other species has invented the tax. They have, however, invented the (virtual) fence. An individual can secure his exclusive benefit from a resource if he actively defends it against rivals.

Many species of animals are territorial, not just birds and mammals, but fish and insects too. They defend an area against rivals of the same species, often so as to sequester a private feeding ground, or a private courtship bower or nesting area. An animal with a large territory might benefit by building a network of good, flat roads across the territory from which rivals were excluded. This is not impossible, but such animal roads would be too local for long distance, high speed travelling. Roads of any quality would be limited to the small area that an individual can defend against genetic rivals. Not an auspicious beginning for the evolution of wheel.

Now I must mention that there is one revealing exception to my premiss. Some very small creatures have evolved the wheel in the fullest sense of the word. One of the first locomotor devices ever evolved may have been the wheel, given that for most of its first two billion years, life consisted of nothing but bacteria (and, to this day, not only are most individual organisms bacteria, even in our own bodies bacterial cells greatly outnumber our 'own' cells).

Many bacteria swim using threadlike spiral propellors, each driven by its own continuously rotating propellor shaft. It used to be thought that these 'flagella' were wagged like tails, the appearance of spiral rotation resulting from a wave of motion passing along the length of the flagellum, as in a wriggling snake. The truth is much more remarkable. The bacterial flagellum is attached to a shaft which, driven by a tiny molecular engine, rotates freely and indefinitely in a hole that runs through the cell wall.

Picture (see suggestions faxed separately to Jeremy Bayston)

The fact that only very small creatures have evolved the wheel suggests what may be the most plausible reason why larger creatures have not. It's a rather mundane, practical reason, but it is nonetheless important. A large creature would need large wheels which, unlike manmade wheels, would have to grow in situ rather than being separately fashioned out of dead materials and then mounted. For a large, living organ, growth in situ demands blood or something equivalent. The problem of supplying a freely rotating organ with blood vessels (not to mention nerves) that don't tie themselves in knots is too vivid to need spelling out!

Human engineers might suggest running concentric ducts to carry blood through the middle of the axle into the middle of the wheel. But what would the evolutionary intermediates have looked like? Evolutionary improvement is like climbing a mountain ("Mount Improbable"). You can't jump from the bottom of a cliff to the top in a single leap. Sudden, precipitous change is an option for engineers, but in wild nature the summit of Mount Improbable can be reached only if a gradual ramp upwards from a given starting point can be found. The wheel may be one of those cases where the engineering solution can be seen in plain view, yet be unattainable in evolution because its lies the other side of a deep valley, cutting unbridgeably across the massif of Mount Improbable.

Richard Dawkins is the Charles Simonyi Professor of the Public Understanding of Science at Oxford University (see http://www.spacelab.net/~catalj/home.html). His books include The Selfish Gene, The Blind Watchmaker, River Out of Eden and, most recently, Climbing Mount Improbable (Viking, 1996).

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Why I am a secular humanist. (views of members of the International Academy of Humanism)(includes related article on secular humanist Sir Isaiah Berlin) Yelena Bonner; Hermann Bondi; Taslima Nasrin; Richard Dawkins; Richard Taylor; John Passmorre; Arthur C. Clarke; Anthony Flew; J.J.C. Smart; Inumati Parikh.

Abstract: Several members of the International Academy of Humanism presented their views on being secular humanists. Some of them believed that their professions, family backgrounds and ideals positively contribute to the values embodied by humanism. They felt that their views correlate well with issues of faith, double standards, and religion. Other members of the academy associated their commitments, ethical conduct and philosophy with various human life issues and concerns.

The members of the International Academy of Humanism reflect on the guiding principles of their lives

The International Academy of Humanism was established in 1985 to recognize distinguished humanists and to disseminate humanistic ideals and beliefs.

YELENA BONNER

A distinguished defender of human rights. Because of her human rights advocacy in the former USSR, she was persecuted by the state, as was her late husband, Andrei Sahkarov, the famous Soviet dissident and Nobel Peace Laureate.

I was born in 1923 and grew up in a time when the word humanism and all concepts that accompanied it were scorned and rejected as bourgeois vocabulary. A common phrase stated that "a communist cannot be a humanist." Many years later, in a Soviet encyclopedic dictionary, I read: ". . . Karl Marx called communism 'real humanism.' Humanism received practical realization in the achievements of socialism, that pronounced as its principle "All for the sake of man, for the good of man."

It was both ridiculous and sad to read this in Gorky, where my husband, Andrei Sakharov, was kept in isolation from the entire world by the whim and arbitrariness of the authorities, and where I was sentenced to exile four years later.

My perception of good and evil were shaped and nurtured by my family, friends, and colleagues. I was 14 years old when my parents were arrested. My father was shot, and my mother was taken away from me and my younger brother for eight years of labor camps and another nine years of internal exile, until the time when the so-called violations of socialist legality were condemned in my country and my parents were exonerated, my father posthumously. Such was communist "humanism."

My family's tragedy did not make me bitter, and I have never held it against my country, never felt my country was culpable. Rather, it was perceived as an act of god, especially since the case of my family was not unique. The same fate had befallen many of my peers - friends and schoolmates. All of us were "strange orphans of 1937," to use the expression coined by the writer Ilya Ehrenburg. In reality "strange orphans" in our society existed since 1917, as well as much later than 1937.

There is no doubt that my family's misfortune left a mark on my psyche, but to all that was evil there was a counterweight in the great Russian literature, and particularly, in poetry, which was fortunately close to my heart from early childhood. Then came World War II with its blood and suffering, with terrible injustice of young lives cruelly cut short - lives of strangers and the most dear ones alike. There was fear. Survival seemed a miracle. A poet's line fully applies to me: "I put the war past me, but it passed through me."

After the war I betrayed my first choice of vocation (I had volunteered to the front after my freshman year of study in Russian language and literature) and entered medical school. I wanted to do good not by word but deed, by everyday work. I have never regretted having become a physician. Even today I relive the sensation of happiness that accompanies the first cry of a newborn in the delivery room; or when entering the ward I would hear two or three dozen babies crying in unison, for feeding time was near. I often found myself smiling as I walked toward their cries. A crying baby is an alive baby.

It was in the family with its misfortunes and joys, in friends and books, in professional life, in the concerns of a woman and a mother that I developed my own perception of the world and of my place in it, my ideals. In essence, they are probably close to the values of humanism.

Translated by Taliana Yakelerich

EDWARD O. WILSON

Emeritus Professor of Entomology at Harvard University and author of numerous widely acclaimed books including Sociobiology.

I was raised a Southern Baptist in a religious environment that favored a literal interpretation of the Bible. But it happened that I also became fascinated by natural history at an early age, and, as a biology concentrator at the University of Alabama, discovered evolution. All that I had learned of the living world to that point fell into place in a wholly new and intellectually compelling way. It was apparent to me that life is connected not by supernatural design but by kinship, with species having multiplied out of other species to create, over hundreds of millions of years, the great panoply of biodiversity around us today. If a Divine Creator put it all here several thousand years ago, he also salted Earth from pole to pole with falsified massive, interlocking evidence to make scientists believe life evolved autonomously. I realized that something was terribly wrong in this dissonance. The God depicted in Holy Scripture is variously benevolent, didactic, loving, angry, and vengeful, but never tricky.

As time passed, I learned that scientific materialism explains vastly more of the tangible world, physical and biological, in precise and useful detail, than the Iron-Age theology and mysticism bequeathed us by the modern great religions ever dreamed. It offers an epic view of the origin and meaning of humanity far greater, and I believe more noble, than conceived by all the prophets of old combined. Its discoveries suggest that, like it or not, we are alone. We must measure and judge ourselves, and we will decide our own destiny.

Why then, am I a humanist? Let me give the answer in terms of Blaise Pascal's Wager. The seventeenth-century French philosopher said, in effect, live well but accept religious faith. "If I lost," he wrote. "I would have lost little: If I won I would have gained eternal life." Given what we now know of the real world, I would turn the Wager around as follows: if fear and hope and reason dictate that you must accept the faith, do so, but treat this world as if there is none other.

SIR HERMANN BONDI

Fellow of the Royal Society and past Master of Churchill College, Cambridge University.

I grew up in Vienna in a nonbelieving Jewish family. But whereas my father liked the forms of the Jewish religion as a social cement (and indeed we kept the household such that we could entertain our numerous Orthodox relatives), I acquired from my mother an intense dislike of the narrowness and exclusivity of the religion. Ethical principles were very strong at home. I soon became clear to me that a moral outlook was at least as strong among nonbelievers. I similarly acquired a strong dislike of the alternative religion, the Catholic Church (in Austria dominant and very reactionary). So I was set early on the path of nonbelief, with strong ethical principles, and soon was ready to declare my attitude. But it was only later that I joined others with a similar outlook in humanist organizations.

My opinion now is that arguments about the existence or nonexistence of an undefined "God" are quite pointless. What divides us from those who believe in one of the faiths claiming universal validity (such as Christianity or Islam) is their firm trust in an alleged revelation. It is this absolute reliance on a sacred text that is the basis of the terrible crimes committed in the name of religion (and of other absolutist faiths such as

Nazism or doctrinaire communism). It is also worth pointing out the appalling arrogance of viewing one's own religion as "right" and all others as "wrong." The multiplicity of mutually contradictory faiths needs pointing out again and again.

Thus I regard humanism not as yet another exclusive faith, but as a determination to stress those issues on which we are all more or less agreed and to relegate to the backburner faiths that divide us. Thus I am a firm secularist, favoring a society and educational system in which those of any religion and of none can feel comfortable as long as they are not aggressive or separatist.

TASLIMA NASRIN

A physician-turned-human-rights-activist and author of the dissident novel Shame. She is exiled from her native Bangladesh.

I was born in a Muslim family. I was forced by mother to read the Koran every morning, to pray namaz, and to fast during Ramadan.

While I was growing up, I was taken by my mother to a pit, a religious cult leader respected by Muslims. He had his own group, who believed in a genie and superstitions. The pit declared that women who laughed in front of men and went out of the house had been taken over by the genie and they were brutally beaten by the pit so that the genie would leave. He gave a scary description of hell. Whoever visited him gave money.

The pir was surrounded by young women who massaged his body and served him whatever he needed. One day, in my presence, he declared that keyamout, the destruction day of the Earth, was coming soon, and that there was no need for women to marry. They should sacrifice their lives for Allah.

I was' horrified to see all the torture he did to get rid of the genie and to listen to the description of hell and waiting for keyamout. But it did not come.

The pir used to treat sick people by uttering sura and beating them. Water was declared holy and said to cure sick people. The sick became sicker after drinking the water. I was also treated by a pit, but I was not cured until my physician father treated me with scientific medicine.

I was encouraged by my father to get a secular education. I learned about the big bang, evolution, and the solar system and became suspicious about Allah's six-day adventure to make the whole universe, the Adam and Eve story, and stories of suns moving around the Earth and mountains like nails to balance the Earth so that the Earth would not fall down. My mother asked me not to ask any questions about Allah and to have blind faith in Allah. I could not be blind.

Then I studied the Koran instead of reading it without knowing the meaning. I found it total bull-shit. The Koran, believed by millions, supported slavery and inequalities among people - in other countries the equality of women had been established as a human right and the moon had already been won by men. Men had the right to marry four times, divorce, have sex with female slaves, and beat their wives. Women were to hide their bodies because the female body is simply a sexual object. Women were not allowed to divorce their husbands, enjoy inheritance, or have their testimony in court considered as seriously as men's. I found that Allah prescribed Muslims to hate non-Muslims and kill apostates.

With my own conscience I found religion ridiculous because it stops freethought, reason, and rationality. My father told me to believe nothing without reason. I did that. I could not believe religion and I became an atheist. I started writing against religion and all the religious superstitions. I was attacked, verbally, physically. The outrage of the religious people was so big that I had to leave my country.

I lived in one of the poorest countries in the world. I saw how poverty was glorified by religion and how the poor are exploited. It is said the poor are sent to the Earth to prove their strong faith for Allah in their miserable life. I have not seen any religious teaching that calls for a cure for poverty. Instead the rich are supposed to make Allah happy by giving some help (Mother Teresa's type of help). The poor should remain poor in society, and opportunists can use them to buy a ticket for heaven.

So I don't accept Allah, His cruel unholiness. I have my own conscience, which inspired me to support a society based on equality and rationality. Religion is the cause of fanaticism, bloodshed, hatred, racism, conflict. Humanism can only make people humane and make the world livable.

RICHARD DAWKINS

Charles Simionyi Professor of Public Understanding of Science, Oxford University, and author of The Blind Watchmaker, The Selfish Gene, and Climbing Mount Improbable.

It is said that, while science can answer many of our questions, it cannot answer all of them. True. But false is the hidden implication that if science can't answer a question it follows that some other discipline can.

Certainly science cannot prove what is right or wrong, but nor can theology. Secular, rationalistic, moral philosophy comes closest by exposing our inconsistencies and double standards.

But science can answer deep questions popularly regarded as outside its remit, as well as those that are universally ceded to it. "Why is there anything rather than nothing?" is often cited as beyond the reach of science, but physics may one day answer it and if physics doesn't, nothing will.

"What is the purpose of life?" already has a straightforward Darwinian answer and is quite different from "What would be a worthwhile purpose for me to adopt in my own life?" Indeed, my own philosophy of life begins with an explicit rejection of Darwinism as a normative principle for living, even while I extol it as the explanatory principle for life.

This brings me to the aspect of humanism that resonates most harmoniously for me. We are on our own in the universe. Humanity can expect no help from outside, so our help, such as it is, must come from our own resources. As individuals we should make the most of the short time we have, for it is a privilege to be here. We should seize the opportunity presented by our good fortune and fill our brief minds, before we die, with understanding of why, and where, we exist.

I'd worry about the humanist label if it implied something uniquely special about being human. Evolution is a gradual process. Humanness is not an all-or-none quality that you either have or don't have. It is a complicated mixture of qualities that evolved gradually, which means that some people have higher doses than others, and some nonhumans have non-negligible doses as well. Absolutist moral judgments founded on the "rights" of all humans, as opposed to nonhumans, therefore seem to me less justifiable than more pragmatic judgments based, for example, on quantitative assessment of the ability to suffer.

The atheist label also worries me because it shouldn't be necessary. Those who don't believe in fairies have no need of a label: the onus of proof is on those who do. I would with positive conviction call myself a scientific rationalist, with a humane concern that is directed toward a target that is both wider and narrower than humanity. Wider because it includes other species and potentially other planets. Narrower because it admits that not all humans are equal.

RICHARD TAYLOR

Professor Emeritus of Philosophy, University of Rochester, and author of Metaphysics.

I am interested in humanism, not as a creed or set of beliefs, but simply as social policy and a way of treating people. Essentially, it is a way of making the conditions of life less burdensome, the relationships between people more fulfilling, and promoting harmony rather than friction. People fare best when they look not to moral rules and principles, not to priests and churches, and not to creeds, but to the actual results of what they do.

Three things have guided me to this approach to life. The first is the wisdom of Socrates, especially as it was developed by the Stoic philosophers of Antiquity and then by such modern Stoics as Henry David Thoreau. They all taught us that we should look first to our own nobility as rational human beings and pay little attention to such things as wealth or power. The second was the philosophy of Arthur Schopenhauer, who located all ethical conduct in our capacity for compassion, not only for other human beings, but for all things that feel pain. And the third was the extraordinary achievements of Joseph Fletcher, whom it was one of my great blessings to know as a friend.

JOHN PASSMORE

Emeritus Professor of Philosophy at Australian National University and President of the Australian Academy of Science. His book Memoirs of a Semidetached Australian details his evolution from Roman Catholicism.

I rebelled as a young boy against the view that the whole of humanity suffers because a single person was disobedient. This I saw as tyranny of the first order. If there was no salvation outside the Roman Catholic Church, I also argued, how could an omnipotent God allow our aborigines to remain unsaved for thousands of years, when they knew nothing of the Church? Later, under the influence of my university philosophy teacher I developed metaphysical arguments against religion.

Critics of humanism sometimes suggest that we make a god of man. But I am willing to admit that there is no deed so dreadful that we can safely say "no human being could do that" and no belief so absurd that we can safely say "no human being could believe that." But on the other side I point to the marvelous achievements of human beings in science and art and acts of courage, love, and self-sacrifice.

I call myself a pessimistic humanist because I do not regard human beings or their societies as being perfectible but a humanist I nonetheless am. And I reflect on the fact that the worst terrorists of the dreadful century I have lived through have felt justified by their belief that they are acting in the interests of some superhuman entity, whether it be God, or History, or the State.

ARTHUR C. CLARKE

Well-known science-fiction writer, author of 2001: A Space Odyssey, and respected futurist.

The greatest tragedy in mankind's entire history may be the hijacking of morality by religion. However valuable - even necessary - that may have been in enforcing good behavior on primitive peoples, their association is now counterproductive. Yet at the very moment when they should be decoupled, sanctimonious nitwits are calling for a return to morals based on superstition. Virtually all civilized societies would give a passing grade of at least 60% to the Ten Commandments (modern translation: "suggested guidelines"). They have nothing to do with any specific faith.

ANTONY FLEW

Professor Emeritus of Philosophy at Reading University in the United Kingdom. His books include The Logic of Mortality and Atheistic Humanism.

My father, like his father before him, was a Methodist minister. At the age of 13, I was sent to the excellent boarding school founded by John Wesley for the education of the sons of his itinerant preachers. I originally rejected the Christian faith - a rejection that occasioned distress to all concerned-during my middle teens. I rejected it then simply and solely because I had come to believe that it could not be true: the belief that the universe is created and sustained by a being both omnipotent and benevolent seemed to me, as it still seems, manifestly incompatible with innumerable, all-too familiar facts. Now - 60 years on - I am more inclined to argue on Humean lines that there is no good evidencing reason for making positive assertions about the putative Cause of the Universe.

J. J. C. SMART

Professor of Philosophy at Australian National University. He recently defended atheism in a debate with J. J. Haldane in the book Atheism and Theism.

My parents were Scots, but I was born and grew up in Cambridge. We were Presbyterians, and I went to a Methodist school. However, on moving to Glasgow, where my father became Regius Professor of Astronomy, my mother, who in Cambridge had some hankering for the Anglican church, became a Scottish Episcopalian and in this was followed by my brothers and then by my father. Last of all I became an Anglican at Oxford.

Nevertheless, I felt uneasy in my churchgoing because I increasingly found it hard to reconcile it with my scientific and philosophical beliefs. I comforted myself with Wittgensteinian double-talk, of which I now feel thoroughly ashamed. For emotional reasons, connected with my affection for my parents, I was a reluctant atheist, but giving up religion brought peace of mind because intellectual conflict was resolved.

INDUMATI PARIKH

Physician and President of the Indian Radical Humanist Association.

In our society woman is on the lowest rung of the social ladder. She does not have freedom to assert herself in fact, she hardly knows what freedom is. So it is the case with most of our poor ignorant men. I thought helping women to be free was more important and would have a lasting effect on the community. In a society fragmented by religion and castes, I thought humanism was the only ideology that would cut across boundaries and help men and women to understand their basic humanness. Being more of an activist than a philosopher, I put my energy to helping women, children, and men at the lowest end of society. I might be one of the few who have worked at developing humanism through work at grassroots level.

Sir Isaiah Berlin, Secular Humanist

When Isaiah Berlin died at 88 on November 5, 1997, the International Academy of Humanism lost one of its most distinguished members - and the world was deprived of a great mind both humane and fecund. The least of his achievements was that he had received 23 honorary doctorates, numerous academic awards, the Order of Merit, and knighthood. The greatest was that he was a philosopher and historian of ideas who spent his life promoting and refining humanist ideals: liberty, social pluralism, critical thought, and the dignity of human beings. Along the way, he attained a passionate life filled with the delights of the intellect, of music, of good conversation, and of friends.

Wonderful Life by Stephen J. Gould. Reviewed by Richard Dawkins in Sunday Telegraph, 25th Feb 1990

If only Stephen Gould could think as clearly as he writes! This is a beautifully written and deeply muddled book. To make unputdownable an intricate, technical account of the anatomies of worms, and other inconspicuous denizens of a half-billion-year-old sea, is a literary tour-de-force. But the theory that Gould wrings out of his fossils is a sorry mess.

The Burgess Shale, a Canadian rock formation dating from the Cambrian, the earliest of the great fossil eras, is a zoological treasury. Freak conditions preserved whole animals, soft parts and all, in full 3-D. You can literally dissect your way through a 530-million-year-old animal. C D Walcott, the eminent palæontologist who discovered the Burgess fossils in 1909, classified them according to the fashion of his time: he ‘shoehorned’ them all into modern groups. ‘Shoehorn’ is Gould’s own excellent coining. It recalls to me my undergraduate impatience with a tutor who asked whether the vertebrates were descended from this invertebrate group or that. "Can’t you see", I almost shouted, "that our categories are all modern? Back in the Precambrian, we wouldn’t have recognized those invertebrate groups anyway. You are asking a non-question." My tutor agreed, and then went right on tracing modern animals back to other modern groups!

That was shoehorning, and that is what Walcott did to the Burgess animals. In the 1970s and 80s, a group of Cambridge palæontologists returned to Walcott’s museum specimens (with some newer collections from the Burgess site), dissected their 3-dimensional structure, and overturned his classifications. These revisionists, principally Harry Whittington, Derek Briggs and Simon Conway Morris, are the heroes of Gould’s tale. He milks every ounce of drama from their rebellion against the shoehorn, and at times he goes right over the top: "I believe that Whittington’s reconstruction of Opabinia in 1975 will stand as one of the great documents in the history of human knowledge."

Whittington and his colleagues realised that most of their specimens were far less like modern animals than Walcott had alleged. By the end of their epic series of monographs they thought nothing of coining a new phylum for a single specimen (‘phylum’ is the highest unit of zoological classification; even the vertebrates constitute only a sub-category of the Phylum Chordata). These brilliant revisions are almost certainly broadly correct, and they delight me beyond my undergraduate dreams. What is irritating is Gould’s grandiloquent and near-disingenuous usage of them. He concludes that the Burgess fauna was demonstrably more diverse than that of the entire planet today, he alleges that his conclusion is deeply shocking to other evolutionists, and he thinks that he has upset our established view of history. He is unconvincing on the first count, clearly wrong on the second two.

In 1958 the palæontologist James Brough published the following remarkable argument: evolution must have been qualitatively different in the earliest geological eras, because then new phyla were coming into existence; today only new species arise! The fallacy is glaring: every new phylum has to start as a new species. Brough was wielding the other end of Walcott’s shoehorn, viewing ancient animals with the misplaced hindsight of a modern zoologist: animals that in truth were probably close cousins were dragooned into separate phyla because they shared key diagnostic features with their more divergent modern descendants. Gould too, even if he is not exactly reviving Brough’s claim, is hoist with his own shoehorn.

How should Gould properly back up his claim that the Burgess fauna is super-diverse? He should - it would be the work of many years and might never be made convincing - take his ruler to the animals themselves, unprejudiced by modern preconceptions about ‘fundamental body plans’ and classification. The true index of how unalike two animals are is how unalike they actually are! Gould prefers to ask whether they are members of known phyla. But known phyla are modern constructions. Relative resemblance to modern animals is not a sensible way of judging how far Cambrian animals resemble one another.

The five-eyed, nozzle-toting Opabinia cannot be assimilated to any textbook phylum. But, since textbooks are written with modern animals in mind, this does not mean that Opabinia was, in fact, as different from its contemporaries as the status ‘phylum’ would suggest. Gould makes a token attempt to counter this criticism, but he is hamstrung by dyed-in-the-wool essentialism and Platonic ideal forms. He really seems unable to comprehend that animals are continuously variable functional machines. It is as though he sees the great phyla not diverging from early blood brothers but springing into existence fully differentiated.

Gould, then, singularly fails to establish his super-diversity thesis. Even if he were right, what would this tell us about ‘the nature of history’? Since, for Gould, the Cambrian was peopled with a greater cast of phyla than now exist, we must be wonderfully lucky survivors. It could have been our ancestors who went extinct; instead it was Conway Morris's 'weird wonders', Hallucigenia, Wiwaxia and their friends. We came 'that close' to not being here.

Gould expects us to be surprised. Why? The view that he is attacking - that evolution marches inexorably towards a pinnacle such as man - has not been believed for 50 years. But his quixotic strawmandering, his shameless windmill-tilting, seem almost designed to encourage misunderstanding (not for the first time: on a previous occasion he went so far as to write that the neo-Darwinian synthesis was 'effectively dead'!). The following is typical of the publicity surrounding Wonderful Life (incidentally, I suspect that the lead sentence was added without the knowledge of the credited journalist): "The human race did not result from the 'survival of the fittest', according to the eminent American professor, Stephen Jay Gould. It was a happy accident that created Mankind" (Daily Telegraph, 22nd January 1990). Such twaddle, of course, is nowhere to be found in Gould, but whether or not he seeks that kind of publicity he all too frequently attracts it. Readers regularly gain the impression that he is saying something far more radical and surprising than he actually is.

'Survival of the fittest' means individual survival, not survival of major lineages. Any orthodox Darwinian would be entirely happy with major extinctions being largely a matter of luck. Admittedly there is a minority of evolutionists who think that Darwinian selection chooses between higher-level groupings. They are the only Darwinians likely to be disconcerted by Gould's 'contingent extinction'. And who is the most prominent advocate of higher-level selection today? You've guessed it. Hoist again!

Richard Dawkins

Biology and Philosophy **19:** 377–396, 2004.

Extended Phenotype – But Not *Too* Extended. A Reply to Laland, Turner and Jablonka

RICHARD DAWKINS
University Museum of Natural History, University of Oxford, UK

I am grateful to the three commentators for their thoughtful and penetrating remarks, and to the Editor for commissioning them. All three have forced me to think, re-opening neural pathways that had suffered neglect as I turned to other things in the years since *The Extended Phenotype* (henceforth *EP*) was published. Their essays raise so many interesting points, it would take another book to reply to them properly. Instead, on the basis that it is better to say a few things thoroughly than lots sketchily, I shall concentrate on what I take to be each author's central argument.

J. Scott Turner and Kevin Laland both, in their different ways, want to go further than me in extending the phenotype. Or so they see it. I am not so sure that further is the right word. Progress implies movement in a useful direction, whereas their extensions – of the organism, and into niche creation – occasionally reminded me of Stephen Leacock's knight who jumped on his horse and galloped off in all directions. I don't intend that flippantly or disrespectfully. The relevant point about the extended phenotype is that it is a *disciplined* extension. There are lots of other tempting 'extensions', which sound similar but take us off in misleading directions. I have always fought shy of misapplying the phrase to a profligate range of apparently plausible extensions.

To take a more extreme example than these commentators consider, when I am asked by lay people (as I frequently am) whether buildings count as extended phenotypes, I answer no, on the grounds that the success or failure of buildings does not affect the frequency of architects' genes in the gene pool. Extended phenotypes are worthy of the name only if they are candidate adaptations for the benefit of alleles responsible for variations in them. I might admit the theoretical possibility of generalising to other kinds of replicators such as memes (or something 'epigenetic' that Eva Jablonka might be able to explain but I wouldn't), in which case my 'no' answer might be softened. But it is enough of a problem already, getting my more hard-headed scientific colleagues to accept the extended phenotype, without arousing their active hostility by mentioning memes (which many see as simplistic) or 'epigenetic

inheritance systems' (which some might write off as obscurantist). I shall return to the important point, which I enthusiastically accept, that replicators do not have to be made of DNA in order for the logic of Darwinism to work.

Laland speaks, I suspect, for all three authors when he espouses cyclical causation. He quotes me as saying

> There are causal arrows leading from genes to body. But there is no causal arrow leading from body to genes.

Laland, who disagrees, generously wants to absolve me from responsibility for this, saying that he is quoting out of context. But I am happy to stand by it. 'Cyclical causation' leaves me cold. I must, however, make very clear that I mean causation statistically. Experimentally induced changes in bodies are never correlated with changes in genes, but changes in genes (mutations) are sometimes correlated with changes in bodies (and all evolution is the consequence). Of course most mutations occur naturally rather than experimentally, but (because corrrelation can't establish causation) I need to focus on 'experimentally induced' in order to pin down the direction of the causal arrow. It is in this statistical sense that development's arrow goes only one way. Attempts to argue for a reverse arrow recur through the history of biology, and always fail except in unimportant special-pleading senses.

Sterelny, Smith and Dickerson (1996), follow Griffiths and Gray in saying "Most acorns rot, so acorn genomes correlate better with rotting than with growth". But this is dead wrong. It misunderstands the very meaning of correlation which is, after all, a statistical technical term. Admitting that most genomes rot, the relevant question is whether *such variation as there may be* in acorn genomes correlates with *such variation as there may be* in tendency to rot. It probably does, but that isn't the point. The point is that the question of covariance is the right question to ask. Sterelny and Kitcher (1988) in their excellent paper on 'The Return of the Gene' are very clear on the matter. Think variation. Variation, variation, variation. Heritable variation; covariation between phenotype as dependent variable, and putative replicator as independent variable. This has been my *leitmotif* as I read all three commentators, and it will be my refrain throughout my reply.

Laland's main contribution to our debate is 'niche construction'. The problem I have with niche construction is that it confuses two very different impacts that organisms might have on their environments. As Sterelny (2000) put it,

> Some of these impacts are mere effects; they are byproducts of the organisms's way of life. But sometimes we should see the impact of organism on environment as the organism *engineering* its own environment: the environment is altered in ways that are adaptive for the engineering organism.

Niche construction is a suitable name only for the second of these two (and it is a special case of the extended phenotype). There is a temptation, which I regard as little short of pernicious, to invoke it for the first (byproducts) as well. Let's call the first type by the more neutral term, 'niche changing', with none of the adaptive implications of niche construction or – for that matter – of the extended phenotype.

A beaver dam, and the lake it creates, are true extended phenotypes insofar as they are adaptations for the benefit of replicators (presumably alleles but conceivably something else) that statistically have a causal influence on their construction. What crucially matters (here's the *leitmotif* again) is that *variations* in replicators have a causal link to *variations* in dams such that, over generations, replicators associated with good dams survive in the replicator pool at the expense of rival replicators associated with bad dams. Note what a stringent requirement this is. Although it is not necessary that we should already have evidence for the replicator-phenotype covariance, extended phenotype language commits us to a can only have come about through replicator-phenotype covariance. The beaver's dam is as much an adaptation as the beaver's tail. In neither case have we done the necessary research to show that it results from gene selection. In both, we have strong plausibility grounds to think it is. The same is not true – would not even be claimed by Laland and his colleagues – of most of their proposed examples of niche construction.

See how different is the 'pernicious' sense of niche construction, the byproduct that I'd prefer to sideline as 'niche changing'. Here, the dam alters the environment of the future, in some way that impinges on the life and wellbeing of beavers in general, and probably others too. Not particularly the welfare of the beavers that built the dam, not even of their children or grandchildren. The dam is good for beaverdom, and more. Beavers, frogs, fishes and marsh marigolds all benefit from a beaver-induced flooding of their niche. This is too loose and vague to count as a true extended phenotype, or as true niche construction. The deciding question is 'Who benefits?' And the reason it matters is that we have a Darwinian explanation of the dam only if dam-friendly alleles of the dam builders themselves benefit at the expense of alternative alleles.

I have no wish to downplay the importance of niche changing. It is a fair description of many important biological events, ranging from the irreversible oxygenation of Earth's early atmosphere by green bacteria and now by plants, to the greening of deserts by ecological successions of plants climaxing in dense forest communities, and including Scott Turner's *heuweltjies* (a fascinating example, of which I had been ignorant).

Most biologists would accept that the beaver dam is an evolved adaptation for the benefit of the genes of the responsible beaver. It would be a bold scientist (James Lovelock, perhaps) who would suggest that the oxygenation of the atmosphere by plants is an adaptation for the benefit of something. The oxygenation of the atmosphere is a hugely important niche change, and woe betide any creature, including any plant, that fails to adapt to it. But the presence of oxygen is nobody's adaptation (or at least, you'll have your work cut out if you want to argue that it is). It is a byproduct of plant biochemistry to which all living creatures, plants included, must adapt. Beaver dams may or may not benefit other beavers, or fishes or water beetles or pondweeds, but such diffuse and unfocused benefits cannot explain why they are there. The only benefits that can be adduced in Darwinian explanation of dams are benefits to the alleles (or other responsible replicators) of the particular beavers that build them. Otherwise, natural selection could not have shaped their evolution. Long-term consequences of niche changing are interesting and important, but they do not provide a Darwinian explanation for why animals change their niches.

Laland pays some lip service to this point when he speaks of ecological inheritance, and says that it resembles the inheritance of territory or property. Local exclusiveness is indeed a vital ingredient of true niche construction. As long as beavers have a high chance passing their lake on to their own grandchildren rather than to somebody else's grandchildren, there is at least a chance of making a workable Darwinian model of niche construction. But the rhetoric of niche construction neglects to follow the lip service, and we are left believing it to be a larger and a grander theory than it really is. Those aspects of niche construction theory that work are already included within extended phenotype theory. Those aspects that don't fit within existing extended phenotype theory don't work.

Don't work as Darwinian adaptations, that is. They can still be interesting in other ways. Earthworms are mentioned by both Laland and Turner, and Laland's splendid 'accessory kidneys' are a gift to Turner and his 'extended organism'. Earthworms radically change the environment in which they, and all other soil organisms including – significantly – rival earthworms live. Again, we certainly have niche alteration but, please, not niche construction until a lot more work has been done to establish this onerous claim.

Ecological succession is a form of niche changing – not niche construction – which follows a repeatable, regular pattern. A desert is colonised by weeds, which then change conditions sufficiently to allow the subsequent invasion by an orderly succession of plants and animals, each wave altering niches in ways that favour the next wave, culminating in a climax forest. But, important and repeatable as ecological succession is, it is not a Darwinian

adaptation on the part of prior member of the succession on behalf of later members. Rather, natural selection within the gene pools of later members of the succession favours those individuals that take advantage of the conditions inadvertently set up by earlier members. The climax forest is a consequence of colonisation by weeds decades or even centuries earlier. The forest is not an extended phenotype of the weeds' genes, nor is it helpful or illuminating to call it a niche constructed by the weeds. The same can be said of the repeatably regular pattern of development of coral reefs, in which generations of polyps build literally on the environment provided by centuries of dead predecessors, and form the foundation – literally and metaphorically – for the marine equivalent of a climax forest community.

Moving on from ecological succession to longer-term processes that look a bit like niche construction, coevolutionary arms races are the outstanding example (Dawkins and Krebs 1979). Predators impose new selection pressures on prey, which respond in evolutionary time such that future generations of prey impose changed selection pressures on future generations of predators. The coevolutionary positive feedback spirals that result are responsible for the most advanced and stunning illusions of design that the natural world has to offer. Again this is a case of animals changing future niches, and changing them in fascinating ways, but again it isn't niche construction, and no helpful purpose is served by lumping it with beaver dams or ecological succession. Understanding requires us to respect clear distinctions.

I don't denigrate niche changing as an important biological phenomenon. But it is not the same thing as true niche construction. Nothing but confusion will result from treating one as a continuation of the other. Since this seems to be a misunderstanding that is eagerly waiting to happen, niche construction is a phrase that should be abandoned forthwith.

That's all I want to say about niche construction. Now, the extended organism, which is J Scott Turner's main contribution to our debate. Turner, like Laland, is aware of the distinction between benefit to the agents responsible for a phenotype, and benefit to the world at large. But, as with Laland, his enthusiasm is in danger of misleading others into forgetting the distinction.

Turner, like Jablonka as we shall see, thinks I am too much of a genetic triumphalist. For the moment I shall leave that on one side while I focus on the wonderful examples of would-be extended organisms that Turner offers us from his own work on termites. Yes, the *Macrotermes* nest, with its underground living and brooding chambers and its overground ventilation apparatus, has many of the attributes of an organism. And yes, it is an intriguing conceit that the fungi are cultivating the termites, rather

than the other way around. Indeed, I said something pretty similar about cellulose-digesting gut microbes in *EP* (p. 208):

> Could the evolution of eusociality in the Isoptera be explained as an adaptation of the microscopic symbionts rather than of the termites themselves?

Once again, note that the extended phenotype is a *disciplined* hypothesis. Speculative as my suggestion was, it was a very specific and tightly limited speculation. Implicitly it postulated *alleles* in microorganisms (or fungi to take in Turner's hypothesis) which *vary* in their effects upon termite social behaviour (or mounds). The fact that there is no actual evidence for either speculation need not worry us at this stage. The point is to be precise about the genetic nature of the speculation. Adaptive hypotheses, however wild and speculative, must not be vaguely Panglossian but precisely limited to specified alleles (or other replicators) which *vary* and which exert a *causal* influence on *variation* in the phenotype of interest.

Let's apply these rigorous standards to the hypothesis that a termite mound is an extended organism. We shall conclude in favour, but it is important to make the case properly, in what I have called a disciplined manner. We shall take for granted the physiological, homeostatic and thermodynamic arguments put by Turner – not because they are unimportant but because he has made them so well. Instead, we concentrate on the genetics (using genes to stand for other conceivable replicators). Mound morphology is sure to be influenced by a number of genes, acting via mound embryology which, in the terms of our discussion, is another name for termite behaviour. These genes are to be found in the cells of many different organisms (using 'organism' in the conventional, non-extended sense). They include genes in the cell nuclei of numerous individual worker termites. They also might include genes in fungi, genes in gut symbionts, and genes in mitochondria or other cytoplasmic elements in the cells of termites, fungi or gut symbionts. So, we potentially have a rich pandemonium of genetic inputs to our mound phenotype, coming at it from as many as three kingdoms.

For my money, the analogy of mound with organism stands up well. The fact that we have a heterogeneously sourced genetic input to the embryology of the phenotype doesn't matter. Lots of genes affect each aspect of my bodily phenotype, including, for all I know, mitochondrial genes. My 'own' nuclear genes tug me in more or less different directions, and my phenotype is some sort of quantitative polygenic compromise. So that is not a difference that might stop the mound being an organism. What, then, is the prime characteristic of an organism? It is that, at least to a quantitatively appreciable extent, all its genes are passed on to the next generation together, in a small 'bottlenecked' propagule. The rationale for this is given in *EP*,

especially Chapter 12, 'Host phenotypes of parasite genes' and Chapter 14, 'Rediscovering the Organism', and I shall not repeat it here. Instead, let's go straight to the termite mound to see how well it holds up. Pretty well. Each new nest is founded by a single queen (or king and queen) who then, with a lot of luck, produces a colony of workers who build the mound. The founding genetic injection is, by the standards of a million-strong termite colony, an impressively small bottleneck. The same is, at least quantitatively, true of the gut symbionts with which all termites in the new nest are infected by anal licking, ultimately from the queen – the bottleneck. And the same is quantitatively true of the fungus, which is carefully transported, as a small inoculum, by the founding queen from her natal nest. All the genes that pass from a parent mound to a daughter mound do so in a small, shared package. By the bottleneck criterion, the termite mound passes muster as an extended organism, even though it is the phenotype of a teeming mass of genes sitting in many thousands of workers.

I won't miss an opportunity to emphasise (though again I shall not repeat the full argument from *EP)* that every organism (conventionally defined) is already a symbiotically cooperating union of its 'own' genes. What draws them, in a Darwinian sense, to cooperate is again 'bottlenecking': a shared statistical expectation of the future. This shared expectation follows directly from the method of reproduction, according to which all of an organism's 'own' nuclear genes, and its cytoplasmic genes for good measure, pass to the next generation in a shared propagule. To the extent that this is true of parasite genes (for example bacteria that travel inside the host's egg), to that very same extent aggressive parasitism will give way in evolutionary time to amicable and cooperative symbiosis. The parasite genes and the host genes see eye to eye on what is an optimum host phenotype. Both 'want' a host phenotype that survives and reproduces. But to the extent that parasite genes pass to their own next generation via some sideways route which is not shared with those of the host genes, to that same extent the parasite will tend to be vicious and dangerous. In such cases, the optimum phenotype from the parasite genes' point of view may well be dead – perhaps having burst in a cloud parasite spores. All our 'own' genes are mutually parasitic, but they are amicably cooperative parasites because their shared route to the future in every generation leads them to 'see eye to eye' on the optimal phenotype.

A termite mound, then, is a good extended organism. A *heuweltjie*, by my reading of Turner's description, is not. It is more like a forest or a coral reef. The genes that contribute to the putative heuweltjie phenotype don't cooperate, because they do not have a statistical expectation of sharing a propagule from the present heuweltjie to the next. Only the contingent centred around the termite genes has that shared expectation. The rest will

join the club later, from different sources, which means that, in the sense I am expounding, it is not a club. Because termite genes, with their fellow travellers, bottleneck their way from mound to mound, we can reasonably think about a form of natural selection which chooses among mounds as extended pheontypes, with adaptive consequences in an evolutionary succession of progressively improving mounds. The same will not be true of a putative natural selection of heuweltjies. Hence my statement that a heuweltjie is not a good extended organism. As in the case of Laland and his niche construction, my request to Turner is to be critical and disciplined with his notion of the extended organism. In his case, apply the bottleneck test.

At this point, I have to pick Turner up on his outrageous statement that "most would agree that the central dogma is essentially dead." It is important to do so because I suspect that many people (perhaps including present commentators who are drawn to 'cyclical causation' and similar notions) have a kind of poetic bias against Francis Crick's central dogma. This may be partly, and understandably, because of Crick's unfortunate choice of the word 'dogma', as opposed to, say, 'hypothesis' or 'theorem'. Crick's own explanation is endearing, as recounted in an interview with Horace Judson (1979). Judson asked him why he had used the word dogma and Crick replied that, because of his religious upbringing, he thought a dogma was a word for something "for which there was *no reasonable evidence.*" He had since been told by Jacques Monod that it means "something which a true believer *cannot doubt*." "You see" Crick roared with laughter as he confided in Judson, "I just didn't *know* what dogma *meant*!" Actually, the Oxford English Dictionary could be used to support either meaning.

The central dogma has been expressed in three versions, whose differences can admittedly lead to confusion: –

1. "Once information has passed into protein, *it cannot get out again*." This is Francis Crick's original wording, at the 1957 meeting of the Society for Experimental Biology and it is, as one would expect, completely clear. Note the prescience with which, long before reverse transcription was discovered, Crick in effect anticipated its irrelevance to his dogma.

> . . . the transfer of information from nucleic acid to nucleic acid, or from nucleic acid to protein may be possible, but transfer from protein to protein, or from protein to nucleic acid is impossible. Information means here the *precise* determination of sequence, either of bases in the nucleic acid or of amino acid residues in the protein (Crick 1957, quoted in Judson 1979).

In this version the central dogma has never been violated and my bet is that it never will. The genetic code, whereby nucleotide sequences are translated into amino acid sequences, is irreversible.

2. “DNA makes RNA makes protein.” This sounds pithy and clever, but it is too pithy and not clever enough. Unfortunately, it is the textbook version that students learn. But it is a summary of research findings, not a theoretical principle like Crick’s ‘dogma’. It is technically violated by reverse transcription but, as we shall see, the fact is trivial and misses the whole point of the dogma.

3. “Embryology is irreversible.” This third version is another way of saying that acquired characteristics are not inherited. It is not particularly molecular in its domain, and it owes more to Weismann than Crick, but it is interesting in being closer to 1 (theoretical principle) than to 2 (summary of known facts, now trivially violated). This version, too, has never been convincingly violated, despite many attempts.

Version 2 is disproved by reverse transcription, but this is a violation of the dogma only if we think the dogma was ever intended to apply to *both* stages of the process: transcription (DNA to RNA) as well as translation (polynucleotide to protein). But such a dogma would have been foolhardy, lacking any basis in theory, and it was explicitly excluded by Crick, with the prescience I have already praised (“the transfer of information from nucleic acid to nucleic acid”). The only ground Crick, or anybody else, ever had for confidence in his central dogma is that the information in a protein is inaccessibly buried inside the knot which the protein ties in itself – *must* tie if it is to perform its role as an enzyme. DNA is not knotted, which is why it is a lousy enzyme but very good at getting its information transcribed (into RNA, as it happens). RNA can tie itself in a kind of knot, enough to secure some sort of enzyme function (which is why some people favour it for a primitive enzyme role as well as a primitive replicator role in theories of the origin of life). But RNA doesn’t always get knotted, which is why it is good at getting its information read and translated into protein. It therefore should have surprised nobody that RNA’s information can sometimes be reverse transcribed back into DNA. Why should it not, given that it maps DNA information one to one, and it is necessarily accessible otherwise it could never be translated into protein? If Version 1, on the other hand, were ever disproved (which I doubt) it would only be by reverse translation of a structural protein like collagen or silk – un-knotted and therefore incapable of functioning as an enzyme.

Prions, contrary to widespread misunderstanding, do not violate Crick’s careful formulation of his dogma. They are replicators after a fashion, in that their alternative conformations are infectious. But the amino acid sequence of a prion is not reverse-translated into the appropriate codon sequence of a polynucleotide (look again at Crick’s prudent wording). Nor is the sequence of amino acids copied by another polypeptide chain. All that happens is that, of the alternative three dimensional conformations of a given polypeptide

sequence, one can, by its proximity, convert another existing molecule to its own shape. Nobody has ever realistically suggested that the amino acid sequence of a prion comes from any source other than DNA.

Dogma 3, the Weismannian or anti-Lamarckian pre-molecular version, is of course, the subject of old arguments, and I shall not get into all that here because it is not what Turner was talking about anyway. I'll just point out that it is a sort of whole-organism version of Crick's molecular dogma, and it is based on a similar theoretical principle. Just as amino acid sequences are inaccessibly buried in a protein, so the genetic instructions that program the development of a body are inaccessibly buried in the body itself. This is not just an empirical fact, which could be disproved at any moment by a Lamarckian finding such as a non-fraudulent case of the midwife toad. It follows from the deeper principle that embryology is not preformationistic. This is the old point about blueprints being reversible, recipes not (*EP* p. 174: 'The Poverty of Preformationism'). You can reconstruct a blueprint from a house, but not a recipe from a cake, an image that I inadvertently borrowed from my friend Patrick Bateson. Bateson's name, by the way, reminds me of my astonishment that Eva Jablonka is not the only author to sympathize with his superficially amusing but deeply misleading suggestion that a gene is a nest's way of making another nest. I shall return to this at the end.

To conclude on the central dogma, that limited part which is essentially dead (RNA cannot be reverse transcribed) should never have been born in the first place. That part of the dogma which deserved to be enunciated (and actually was enunciated by Crick) is most certainly not dead, not essentially dead, not even the tiniest bit ailing.

Let me now turn to Eva Jablonka. She, like the other two commentators, has read *EP* with flattering attention, and I am grateful for her, and their, clear disavowal of several potential misunderstandings. Genetic determinism does not follow from gene selectionism. Nor does naïve adaptationism. She is also admirably clear that "when geneticists talk about 'genes for', they are talking about genetic *differences* that make a *difference* to the phenotype." I suspect that she, like Turner, wants to have nothing to do with what he calls 'genetic triumphalism'. I agree, insofar as the 'gene' role in Darwinian models does not have to be played by DNA. If I am a triumphalist, it is a replicator triumphalist. I am happy to go along with what Sterelny (2000) has dubbed 'the extended replicator'. Indeed, I was at some pains to extend the replicator myself, in *EP*, listing several of the alternative replicators mentioned by today's three commentators: paramecium cilia, and memes, for instance. I would certainly have included prions if they had been discovered then. Jablonka is right when she says:

> Following the fortunes of heritably variable phenotypic traits in populations is common practice in evolutionary biology. We measure the genetic component of the variance in a trait in a population; models of phenotypic evolution are regularly constructed (e.g. most game theoretical models); and paleontological data, which is mostly based on morphological traits, is an accepted source of insights about evolution. Since for an entity to count as a 'fitness bearer' – a unit of adaptive evolution – it has to show (frequent) heritable variation in fitness, variant phenotypic traits are much better candidates than genes for this role.

I agree. But Jablonka should not be *surprised* that I agree. I devoted a chapter, 'Selfish Wasp or Selfish Strategy' to developing precisely the notion that a Darwinian replicator does not have to be specified as DNA, but can be a Maynard Smithian 'strategy' defined in a minimalist 'like begets like' fashion. Presumably DNA is involved in practice, but it is not a specified part of the reasoning. Jablonka's 'heritably varying phenotypic trait' is close to Williams's classic definition of the 'gene', which was the same sense in which I later called it 'selfish'.

> If there is an ultimate indivisible fragment it is, by definition, 'the gene' that is treated in the abstract definitions of population genetics (Williams 1966).

The Williams gene is only incidentally made of DNA. He later (1992) called the generalised version (what I would call a replicator) a codex, adding, "A gene is not a DNA molecule; it is the transcribable information coded by the molecule." I agree with Sterelny (and I am sure Williams would too):

> My own view is that DNA-based transmission of similarity *is* of fundamental significance. But that is not built into the structure of the theory.

Quite so. If Jablonka manages to convince the scientific community that some sort of complex feedback system of developmental cycles constitutes a true replicator, over and above its DNA content, I would be happy to embrace it. But, for the third time and at the risk of seeming pedantic, I insist on tight discipline. The criterion for recognizing a true replicator for a Darwinian model is a rigorous one. The putative replicators must vary in an open-ended way; the variants must exert phenotypic effects that influence their own survival; the variants must breed true and with high fidelity such that, when natural selection chooses one rather than its alternative, the impact persists through an indefinitely large number of generations (more precisely, survives at a high enough rate to keep pace with mutational degredation). If there is something other than DNA that meets these criteria, let us by all means include it, with enthusiasm, in our Darwinian models. But it really

must meet those criteria. Sterelny (2000) has a similar list, which he calls Hoyle Conditions because he imagines tailoring a form of life to colonise an empty world from outer space.

I am interested in the possibility that Jablonka really has a good new candidate for a true replicator, but I have to say that the use of the word 'epigenetic' makes for an unpropitious start – associated as it (no doubt unfairly) has become with obscurantism among biologists.[1] Epigenetic should be reserved for its true meaning as a historical school of embryology, hard to define except as a nebulous antonym of preformationist – which is not nebulous, is easy to define,and clearly wrong. If you want to propose an alternative replicator, extragenetic, paragenetic or quasigenetic might all be happier choices than epigenetic – not on grounds of strict etymology but because epigenetic is weighed down by inappropriate historical associations. A meme might be a quasigenetic replicator. A prion is perhaps a paragenetic replicator. Both fall down on some, but not all, of my criteria. Prions fail on the criterion of open-ended variation: the repertoire of variants for a given prion is limited to two. And memes – no, for heaven's sake don't let's get into memes now: I'll save them up to make a more worthwhile point, in a moment.

Jablonka's use of Waddington's canalization is potentially interesting (Waddington, numerous references, e.g. 1977). This isn't quite how she puts it, but canalization could play a 'self-normalizing' role. Let me explain self-normalizing, using memes in the way they are perhaps best used – by analogy. When I was a small boy at boarding school, we had to take turns in saying a goodnight prayer, kneeling up on the ends of our beds with our hands together. I can now reconstruct that the original prayer must have been that popular Evensong Collect, "Lighten our darkness, we beseech Thee O Lord, and by Thy great mercy defend us from all the perils and dangers of this night. . . ." But we only ever heard it said by each other, and none of us had a clue what most of the words meant. By the time I arrived at the school, the first line had become – and I inherited it, garbled it further, and passed it on – something like this: "Lutnar darkny sweep seech Theo Lord. . . ."

The childhood game of Chinese Whispers (American children call it Telephone) is a good model for such degradation of messages handed down over memetic 'generations'. Twenty (say) children are lined up, and a message whispered into the ear of the first. She repeats it in the ear of the second, and it passes on down the line until the twentieth child finally speaks it aloud to the assembled company – who are amused or dumbfounded at how much it has degenerated when compared with the original. As experimental memeticists we might find Chinese Whispers a useful test bed. We would compare the fidelity of various classes of message. Compare, for example, a message in a

language unknown to the children with a message they can understand. My school prayer was a sort of inadvertent running of this experiment.

When a child listens to a message and passes it on, there are two ways he can do it, one being 'normalizing' and the other not. The non-normalizing method is to imitate the sounds, phoneme by phoneme. That is approximately what the members of my dormitory were doing with 'Lighten our darkness'. The normalizing method is to treat the message, not as a set of phonemes to be imitated, but as a set of words to be looked up in a mental dictionary and then re-rendered in the child's own accents.

Cananalizing is not synonymous with digitizing but it has a similar effect. Digital codes such as DNA are protected from continuously distributed degradation, while at the same time becoming vulnerable to discrete error. Both are potential normalizing agents. Normalization is even more clearly illustrated by another meme which spread as an epidemic or craze at my father's school, and with which I re-infected the same school when I went there 26 years later. It consisted of the instructions for making an origami Chinese Junk.

> It was a remarkable feat of artificial embryology, passing through a distinctive series of intermediate stages: catamaran with two hulls, cupboard with doors, picture in a frame, and finally the junk itself, fully seaworthy or at least bathworthy, complete with deep hold, and two flat decks each surmounted by a large, square-rigged sail (Dawkins 1999).

One could imagine a version of Chinese Whispers in which what passed down the line was a hands-on demonstration of this particular skill. Unlike a drawing of a junk, which would degrade horribly down the line, the origami instructions have a good chance of making it, intact, to the twentieth child, for the reason that they are self-normalising. Here are the first five instructions for making a Chinese junk.

1. Take a square sheet of paper and fold all four corners exactly into the middle.
2. Take the reduced square so formed, and fold one side into the middle.
3. Fold the opposite side into the middle, symmetrically.
4. In the same way, take the rectangle so formed, and fold its two ends into the middle.
5. Take the small square so formed, and fold it backwards, exactly along the straight line where your last two folds met.

And so on, through 20 or 30 instructions of this kind. These instructions, though I would not wish to call them digital, are potentially of very high fidelity, just as if they were digital. This is because they all

> make reference to idealised tasks like 'fold the four corners exactly into the middle'. If the paper is not exactly square, or if a child folds ineptly so that, say, the first corner overshoots the middle and the fourth corner undershoots it, the junk that results will be inelegant. But the next child in the line will not copy the error, for she will assume that her instructor *intended* to fold all four corners into the exact centre of a perfect square. The instructions are self-normalising. The code is error correcting (Dawkins loc. cit.)

I hope the analogy to Waddingtonian canalization, and Jablonka's usage of it, is becoming clearer. A canalized embryology is resistant to change. Resistant, at least, to small, continuously distributed change, although large changes can kick Waddington's rolling ball out of the groove into a neighbouring one. Even this subtlety is well covered by the origami analogy:

> I haven't done it, but I will make the following confident prediction, assuming that we run the experiment many times on different groups of 20 children. In several of the experiments, a child somewhere along the line will forget some crucial step in the skill taught him by the previous child, and the line of phenotypes will suffer an abrupt macromutation which will presumably then be copied to the end of the line, or until another discrete mistake is made. The end result of such mutated lines will not bear any resemblance to a Chinese junk at all. But in a good number of experiments the skill will correctly pass all along the line, and the 20th junk will be no worse and no better, on average, than the first junk. If we then lay the 20 junks out in order, some will be more perfect than others, but imperfections will not be copied on down the line. If the fifth child is hamfisted and makes a clumsily asymmetrical or floppy junk, his quantitative errors will be corrected if the sixth child happens to be more dexterous (Dawkins loc. cit.).

The twenty junks will not exhibit a progressive deterioration, as they would in a game in which each child was asked to imitate a *drawing* done by the preceding child. In the light of this memetic analogy, I take it that Jablonka is proposing that canalization increases the *fidelity* of her putative replicator by resisting change, at least up to the point where the Waddingtonian 'rolling ball' is kicked into a neighbouring channel. If I am right, it is a worthwhile suggestion, which needs to be worked out more thoroughly. My hunch is that it will come to nothing, but it is interesting, nevertheless. It could have the makings of a new kind of replicator theory.

I said that I'd return to Pat Bateson and The Selfish Nest. Jablonka sympathizes with Bateson's opinion that the developmental cause-effect relationship between genes and phenotypes is circular, and that a gene can

therefore be thought of as a nest's way of making another nest. Sterelny, Smith and Dickerson (1996) go so far as to say, "Bateson was right"! No, Bateson was not right, he wasn't even close to being right, for the reasons I gave in *EP*, reasons mentioned by Jablonka, and by Sterelny et al. but, to my bafflement, not accepted by them.

> Dawkins rejected this idea on the grounds that variation is not transmitted [the *leitmotif* again, RD]. Whatever the merits of The Selfish Nest as an evolutionary hypothesis, it cannot be rejected on those grounds. First, because Dawkins here appeals to the same criterion used to exclude asexual organisms as replicators; a criterion unsatisfactory on other grounds. Second, it is not in general true. Environmentally altered patterns in cilia are inherited through fission. . . . Variation in both nesting materials and nest siting can be transmitted (Sterelny, Smith and Dickerson 1996).

My grounds for excluding asexual organisms as replicators were, in my opinion, very satisfactory. I'll reply to what Sterelny et al. went on to say:

> Dawkins appealed to fidelity to argue that asexual organisms are not replicators [*EP* p. 97]. An aphid that loses one of its legs will still give birth to six-legged offspring. . . . This criterion backfires against genetic replication. Many changes in the germline genes are not passed on. The point of the proofreading and repair mechanisms is to avoid the transmission of changes. So if genes are replicators, some changes in replicators need not be passed on; those censored by the proofreading and repair mechanisms. But then we can see the production of a six-legged aphid from its eventually five-legged forebear as a triumph of the aphid's proof-reading and correction mechanism.

Nice try. Won't do. Certainly, not all genetic changes are passed on. But no gene selectionist ever said they were. The point is that some genetic changes are passed on (otherwise there could be no evolution) but *no* environmentally acquired changes are passed on (at least not with enough high fidelity to have a chance of surviving into the indefinite future). Or, if they are passed on, they are replicators by definition and that takes care of the second part of Sterelny et al.'s objection. If environmentally altered variations in patterns of cilia are inherited (as I was happy to admit in *EP*, p. 176–177) they are replicators by definition and therefore, for present purposes, honorary genes. Aphid clones are not replicators for precisely the reason that I originally gave.

Jablonka and the school of thought dubbed 'Developmental Systems Theorists' think that the complexity of embryonic development somehow detracts from the validity of the gene's eye view of Darwinism. But we must not allow complexity to become a euphemism for muddle. Gray (1992) in 'Death of the Gene: Developmental systems strike back' says:

> . . . genetic factors do not replicate themselves nor do they physically persist across generations [*of course* they don't, that is the point of Williams's 'codex', RD]. They are replicated as part of the *reproduction* of developmental systems. Remove some part of that developmental system and genetic replication may be changed or impaired. In this sense genes are no different from any other developmental interactant.

Oh yes they are. You may be sick of hearing my *leitmotif* but we are just going to have to play it one more time as a finale. It doesn't matter how complicated the developmental support structure, nor how utterly dependent DNA may be upon it, the central question remains: which elements of the Great Batesonian Nexus of development have the property that *variations* in them are replicated, with the type of fidelity that potentially carries them through an indefinitely large number of evolutionary generations? Genes certainly meet the criterion. If anything else does, let's hear it and, if the case is well made, let's by all means elect it into membership of the replicator club. But that is a separate issue. The complexity of development itself is an obscurantist red herring. Complexity is tamed by the statistics of variation. That, for heaven's sake, is why the analysis of variance was invented, and heritability is just a special case of the analysis of variance.

This should be our response to Jablonka too, and the other commentators to the extent that they invite it. We can clearly distinguish two kinds of objection to the gene's-eye-view of selection. There is the 'genes are not the only replicators' class of objection. Let's embrace that one with open arms in principle, even though we may have to bend over backwards to accommodate some pretty specious special pleading in practice. And there is the 'Dear oh dear, development is a terribly complicated nexus, isn't it?' style of objection. Don't embrace that one. Lance the boil of obfuscatory complexity with a laser scalpel. Or mutate the metaphor, and shine a laser beam of clear statistical reasoning on what really matters, which is transgenerational covariance.

Gray repeats his error with abandon. Just one more example, in case I still have failed to get the point across.

> Lots of fun could be had with these environmentalist inversions of the gene's eye view of evolution. For example, instead of the story of the selfish gene, imagine the story of the selfish oxygen. In the evolution of the earth's atmosphere oxygen was engaged in intense competition with other atmospheric gases. With the construction of green plants oxygen developed a vehicle for its efficient replication. Chlorophyll containing organisms were thus just oxygen's way of making more oxygen (Gray, loc. cit.).

I find it disturbing that anybody could be so misled as to see this as good satire, yet I have a horrible suspicion that more than one of our three

commentators would be tempted by it. If there were alternative versions of oxygen that *varied* in their talent for exploiting plants and passed on those talents to daughter oxygens, Gray would have a point. But there aren't. Oxygen is oxygen is oxygen. There is nothing there to select.

The quality of hi-fi variation is not something cheap and easy, possessed by Bateson's nests, Gray's oxygen and just about any other unit you could think of from the world of chemistry. On the contrary, it is a precious, rare, onerous, difficult talent, possessed by genes and computer viruses and a few other things – but *genuinely* few – every one of which needs rigorous defence before biologists of critical intelligence should accept it into their Darwinian models. If it were as easy as Gray jokes, the origin of life – which means the origin of self-replicated variation – would not be the major theoretical conundrum that it is.

Hi-fi variation is not some kind of arbitrary criterion, required for scripturally dogmatic reasons stemming from the teachings of Saint George Williams. It follows from first principles, the principles that tell us why any of this matters in the first place. We are interested in evolution by natural selection. In order for anything to evolve by natural selection, there has to be variation in something that is both potentially long lasting and causally powerful, so that there emerges a difference, on the evolutionary timescale, between the state of the world if one variant survives compared with the state of the world if an alternative variant survives. If neither variant survives more than a couple of generations anyway, we are not talking evolution at all. That is why hi fi variation matters and that is why Gray's oxygen joke, Bateson's nest joke and others of their kind are not funny. There may be backwards arrows in all sorts of other senses but, in the sense that specifically matters for Darwinian evolution, the causal arrow of biological development from genotype to phenotype really is a one-way arrow.

What should I say if invited to give my own 21-year retrospective on *The Extended Phenotype?* I think Laland and Jablonka are right that the gene's-eye-view – the part of the theory that I am not responsible for inventing – really has moved to the forefront of the minds of ethologists, behavioural ecologists, sociobiologists and other evolutionary biologists in the field. This is certainly gratifying. Moreover, the study of what some people call 'ultraselfish genes' or 'selfish genetic elements' has become a major growth industry.

But the part of the theory that is wholly my own, the extended phenotype itself, unfortunately cannot yet make the same claim. It lurks somewhere near the back of some biologists' minds, but not in the lobes that plan research in the field. Twenty-one years ago, I said that nobody had done a genetic study using animal artefacts as the phenotype. I think that is still true. I would admit

to disappointment, except that it invites the obvious retort: why don't you get out there and do it yourself, then? It is a fair point. I should. Maybe I will. Idleness is a poor excuse, and preoccupation with writing books only slightly better.

Meanwhile, let me conclude with an idle pipedream. It is the beautiful Indian summer of 2010, opening day of EPI, the Extended Phenotypics Institute in one of our great university cities. After the formal unveiling by a Nobel Prizewinning scientst (Royalty wasn't considered good enough), the guests are shown wonderingly around the new building. There are three wings: the Zoological Artefact Museum (ZAM), the laboratory of Parasite Extended Genetics (PEG), and the Centre for Action at a Distance (CAD).

The artefact museum is a zoological equivalent of Oxford's Pitt Rivers, which differs from other museums of human artefacts in that its specimens are grouped functionally instead of by region of origin. Instead of sections devoted to Polynesia, Africa, Asia and pre-Columbian America, the Pitt Rivers has sections devoted to fishing nets, to wind instruments, to boats, to butchering tools, to ornamental headdresses, all gathered together with their own kind regardless of their geographic provenance. EPI's museum has all the nests together, whether made by birds, insects, mammals or spiders; all the hunting nets in another case, whether made by spiders or caddis larvae; all the sexually alluring bowers in a third, and so on. Where possible, each specimen is housed next to human equivalents, and next to functionally analogous pieces of animal anatomy: lyre bird tails next to bower bird bowers, thermoregulatory heat-exchange organs next to termite mound chimneys, and so on. A central display case shows the comparative anatomy of bird nests, each one perched on its rightful branch of a phylogenetic tree: an expanded version of the tree drawn by Winkler and Sheldon (1993) for Swallows' nests.

All around the Museum are laboratories devoted to the genetics of animal artefacts. Some would say this is, strictly speaking, the genetics of their builders, but of course the ethos of EPI acknowledges no such distinction. Artefact genetics differs from conventional genetics in that the genes whose effects bear upon any one phenotype may come from different 'organisms'. Geneticists are used to handling such summations and epistatic interactions within 'organisms' under the heading of polygenes, and our extended geneticists are well versed in the mathematical theory of polygenic inheritance (Falconer 1981). Studies in the artificial selection and genetic manipulation of silkworm cocoons enjoy a generous grant from Japan, which also supports a major project on the genetics and polymer chemistry of other silk artefacts such as spider webs and caddis larva fishing nets. The artefact museum serves as the home base for field studies of the memetics of tool making and tool use in chimpanzees, sea otters, Galapagos woodpecker finches and others.

The other two wings can be imagined by analogy with the first, and by reference to Chapters 12 and 13 of *EP*. PEG is the most prosperously endowed part of the Institute, because of the medical importance of parasite genes expressing themselves in host phenotypes. As for CAD, its generous grant from agricultural funds is prompted by the hope that artificially synthesized pheromones could revolutionise pest control. But CAD's total remit embraces nothing less than the entire field of animal communication studies and, broader yet, networks of interaction in community ecology.

In all three wings, familiar phenomena are studied from an unfamiliar perspective: different angles on a Necker cube. Everyone knows that parasites manipulate their hosts. The extended geneticists of PEG differ only in that they study variations in host behaviour and morphology as phenotypes of parasite genes. Even more than their colleagues in the artefact museum, they are never far from their well-thumbed copy of Falconer's textbook, and they are as nearly as possible indifferent to their polygenes' 'organisms' of origin. The ethologists and zoosemioticists of CAD run the risk of being mistaken for Gaian eco-mystics, as they immerse themselves in the dawn chorus and call it extended embryology. But, like their colleagues in the other two wings of EPI, they pride themselves on the disciplined rigour of their theory. The motto carved over the main door of their Institute is a one-locus mutation of St Paul: "But the greatest of these is clarity."

Note

[1] I am reminded of a satirical version of Occam's Razor, which my group of Oxford graduate students mischievously attributed to a rival establishment: "Never be satisfied with a simple explanation if a more complex one is available". And that in turn reminds me to say that Laland has missed the irony in my apparent espousal of Bateson's "Great Nexus of complex causal factors interacting in development."

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The Wars Over Evolution - New York Review of Books - By Richard C. Lewontin

The Evolution–Creation Struggle

by Michael Ruse

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Harvard University Press, 327 pp., $25.95

Not By Genes Alone: How Culture Transformed Human Evolution

by Peter J. Richerson and Robert Boyd

University of Chicago Press, 332 pp. $30.00

1.

The development of evolutionary biology has induced two opposite reactions, both of which threaten its legitimacy as a natural scientific explana-tion. One, based on religious convictions, rejects the science of evolution in a fit of hostility, attempting to destroy it by challenging its sufficiency as the mechanism that explains the history of life in general and of the material nature of human beings in particular. One demand of those who hold such views is that their competing theories be taught in the schools.

The other reaction, from academics in search of a universal theory of human society and history, embraces Darwinism in a fit of enthusiasm, threatening its status as a natural science by forcing its explanatory scheme to account not simply for the shape of brains but for the shape of ideas. The Evolution–Creation Struggle is concerned with the first challenge, Not By Genes Alone with the second.

It is no surprise that Cardinal Christoph Schцnborn has recently chosen the Op-Ed page of The New York Times to enunciate the doctrine on evolution of the new Benedictine papacy.[1] Political and cultural struggle over the origin of life and of the human species in particular has been a characteristically American phenomenon for a century, providing Europeans (the French in particular) with yet another example of la folie des Anglo-Saxons. In his essay, Cardinal Schцnborn accepts that human and other organisms have a common ancestry and, by implication, that the species on earth today have evolved over a long period from other species no longer extant. That is, he accepts the historical fact that life has evolved. He distinguishes this acceptable fact of evolution from what he characterizes as the unacceptable "neo-Darwinian" theory that, in the words of the offi-cial 1992 Catechism of the Catholic Church of which he was an editor, evolution is "reducible to pure chance and necessity." He rejects, as he must, the Newtonian notion of first cause, that at the beginning God only created a material mechanism with a few basic molecular laws and that the rest of history has simply been the consequence of this mechanism.

In the evolutionary process, he writes, there must have been "an internal finality," the Divine plan. He calls attention to the fact that John Paul II, who endorsed the science of evolution in his 1996 address to the Pontifical Academy of Sciences, nevertheless insisted in his other writings that there must also be such a principle of finality and direction built into the material process. Such internal finality and direction cannot be omitted from the minimal Christian position. For if evolution is only the consequence of random mutations, none of which needs to have occurred, and if the subsequent fate of those mutations is subject only to the relative ability of their carriers to reproduce and to survive catastrophes of the environment that eliminate species and make room for new ones, then rational beings capable of moral choices might never have come into existence. But without such beings the concept of Redemption is unintelligible. Christianity demands, at the very least, the inevitable emergence of creatures capable of sin. Without a history of human sin, there is no Christ.

Everything else is up for grabs. Neither the Vatican nor much of quite conventional Protestant theology demands that one take the story in Genesis 1 literally. Even William Jennings Bryan, famous as the prosecutor in the Scopes trial in 1925, when called as a witness for the defense, confessed that he did not much care whether God took six days or six hundred million years to create the world. Moreover, even the minimalist Christian position does not require the abandonment of the neo-Darwinian view of the mechanism of evolution. It is quite possible to argue, as some of my believing religious colleagues do, that God set the stage for evolution by natural selection of undirected mutations, but that He reserved the ancestral line destined to become human for special preservation and guidance.

What, then, is the source of the repeated episodes of active political and social agitation against the assertions of evolutionary science? One apparent answer is that it is the expected product of fundamentalist belief, which rejects the easy compromises of liberal exegesis and insists that every word in Genesis means exactly what it says. Days are days, not eons. But there's the rub. A literal reading of Genesis tells us that it took God only three days to make the physical universe as it now exists, yet nuclear physics and astrophysics claim a very old stellar system and provide the instruments for the dating of bits and pieces of the earth and of fossils spanning hundreds of millions of years. So why aren't Kansas schools under extreme pressure to change the curriculum in physical science courses? Why should physicists be allowed to propagate, unopposed, their godless accounts of the evolution of the physical universe? Something more is at stake than a disagreement over the literal truth of biblical metaphors.

One way to understand the particular vulnerability of the science of biological evolution to religious attack is to blame it on the biologists. That is the message of Michael Ruse's The Evolution–Creation Struggle. Ruse, a well-known philosopher of science, is not a creationist and is careful to align himself with the Darwinian explanation of the origin and evolution of species. He identifies his position on the existence of a higher power as "somewhere between deist...and agnosticism." That is, he is committed to giving natural explanations of natural phenomena as a methodological principle, but he is not absolutely sure that every aspect of the world is, in fact, nothing but the interactions of matter according to natural laws.

His chief quarrel is not with evolutionary biology as a technical scientific discipline, or even with its claim that the evolution of species has been a purely material process, but rather with what he calls "evolutionism," a commitment to a principle of universal long-term progress in the biological, social, cultural, and political worlds. He identifies evolutionism as a form of religion and portrays the conflict between creationism and evolutionism as a fight between two religious doctrines, a struggle between premillenialism, the doctrine that earthly perfection will only be achieved after, and as a consequence, of the Second Coming, and postmillenialism, the view that Christ will return, if at all, only after earthly paradise has been achieved. Ruse sees evolutionary biology as having been permeated by the idea of pro-gress and so, as a rhetorical device, iden-tifies it as "postmillenial," but without any commitment to the Second Coming.

Ruse is certainly correct that notions of progress have recurred repeatedly in evolutionary biology, especially in the nineteenth century. However, it is not the ideology of progress that has characterized evolutionary theory, not even at its nineteenth-century origins. Rather it was change, ceaseless change, that was the ideological leitmotif of a revolutionary era. Ninety years before Darwin's On the Origin of Species, Denis Diderot had his dreaming philosopher d'Alembert ask, Who knows what races of animals preceded ours? Who knows what races of animals will succeed ours? Everything changes, everything passes, only the totality remains.[2]

Nine years before the appearance of the Origin, Tennyson's In Memoriam echoed Diderot. Is nature, while making individual death inevitable, at least careful of the type?

So careful of the type? But no.
From scarped cliff and quarried stone
She cries, "A thousand types are gone:
I care for nothing, all shall go."

Herbert Spencer in his Progress: Its Law and Cause (1857) argued for change as a general phenomenon, as a "beneficent necessity," citing historical transformation in music, poetry, society, government, and language. But even Spencer defined progress in a way that accorded with contemporary changes in social and economic relations:

Leaving out of sight concomitants and beneficial consequences, let us ask what progress is in itself.

From the earliest traceable cosmical changes down to the latest results of civilization, we shall find that the transformation of the homogeneous into the heterogeneous is that in which progress consists.

What could have seemed more obvious to the mid-nineteenth-century observer than the transformation of a relatively "homogeneous" society, characterized by the "simple" agrarian life with the rural village its center, into one marked by the booming, buzzing "heterogeneous" confusion of life in industrial Manchester and London?

Darwin himself avoided implications of general progress or of directionality. It should be noted that his great work is unideologically titled On the Origin of Species, not On Evolution, and the word "evolution" nowhere appears in the first edition of that work, which thus neatly avoids, by intent or not, any implication of an unfolding of a progressive program. Equally revealing is the title of his work on human evolution, a field in which its more recent practitioners find notions of progress and directionality all too tempting. Darwin's title is The Descent of Man.[3] The theory of evolution was not a product of a commitment to progress but a reaction to a consciousness of the instability of the social structures that characterized the bourgeois revolutions and the radical changes in them. The Founding Fathers did not promise us all eventual happiness, but only the freedom to run in pursuit of it.

Despite Darwin's caution, notions of progress and directionality have indeed reappeared from time to time in evolutionary theory, especially in discussions of human physical and cultural change. However, the modern empirical science of evolutionary biology and the mathematical apparatus that has been developed to make a coherent account of changes that result from the underlying biological processes of inheritance and natural selection do not make use of a priori ideas of progress. It is true, as Ruse points out, that two of the originators of the mathematical formulation of evolutionary dynamics were ideologically committed to some form of meliorism, if not perfection. Ronald Fisher in England was an advocate of eugenics, and both he and Sewall Wright in America formulated the principle of natural selection as a process of increasing, from generation to generation, the average fitness of members of a breeding population. Yet these formulations make no predictions about a general progress of species.

This may seem odd, since the process of natural selection is supposed to make organisms more fit for their environment. So why does evolution not result in a general increase of the fitness of life to the external world? Wouldn't that be progress? The reason that there is no general progress is that the environments in which particular species live are themselves changing and, relative to the organisms, are usually getting worse. So most of natural selection is concerned with keeping up. Certainly quite new kinds of making a living have been occasionally exploited in evolution, but every species eventually becomes extinct (99.9 percent already have) and no way of making a living will be around forever.[4] Judging from the fossil record a typical mammalian species lasts roughly ten million years, so we might expect to last another nine million unless, as a consequence of our immense ability to manipulate the physical world, we either extinguish ourselves a good deal sooner or invent some extraordinary way to significantly postpone the inevitable.

One of the most-cited results in evolutionary biology is the study by the University of Chicago biologist Leigh Van Valen of the longevity of Tennyson's "types." Van Valen reasoned that if there is a general increase in the fitness of organisms then the length of time between the first appearance of a kind of organism in the fossil record and its eventual extinction should increase over the long run of geological time. But that is not what has happened. He found that the average length of time from origin to extinction of an invertebrate, as measured in the fossil record, has not changed over evolutionary time. We have no evidence that this is not true for species in general. So despite natural selection, things are not getting any better over the long run. Van Valen called this phenomenon the evolutionary "Red Queen," after the character in Through the Looking Glass who found it necessary to run constantly just to keep up with a world that was constantly moving beneath her. Unfortunately, in real life, the Queen inevitably will tire, stumble, and be swept away.

If we accept that evolutionary biology is not, in fact, committed to progress, then we cannot accept Ruse's central contention that

> in both evolution and creation we have rival religious responses to a crisis of faith—rival stories of origins, rival judgements about the meaning of human life, rival sets of moral dictates and, above all, rival eschatologies [i.e., premillenarian vs. postmillenarian].

Flowing from his view that scientific evolutionary biology can be turned into a kind of religion, Ruse is worried that the commitment to using only natural phenomena in the attempt to explain the history and variety of organisms is a "slippery slope" down which evolutionists may glide from the firm surface of hard-minded methodology, of which Ruse approves, into the slough of unreflective metaphysical naturalism. We demand that our scientific work be framed with reference only to material mechanisms that can, at least in principle, be observed in nature because any other method would lead us into a hopeless morass of uncheckable speculation that would be the end of science. But we should not, in Ruse's view, confuse that rule of conduct with a revelation of how the world really works. Maybe God is lurking out there somewhere but He doesn't leave any residue in our test tube, so we will be tempted to assume He doesn't exist.

This is a philosopher's worry that does not, as far as I can tell, correspond to the way people really acquire their views of reality. Some may have had mountaintop conversions at some point in their lives, while others experience a crisis of faith as they mature. Theodosius Dobzhansky, the leading empirical evolutionary geneticist of the twentieth century, who spent most of his life staring down a microscope at chromosomes, vacillated between deism, gnosticism, and membership in the Russian

Orthodox Church. He could not understand how anyone on his or her deathbed could remain an unrepentant materialist. I, his student and scientific epigone, ingested my unwavering atheism and a priori materialism along with the spinach at the parental dinner table.
2.

The present struggle over evolution is often seen by defenders of Darwinism as a culture war in which creationism is a part of a general right-wing ideology that justifies an authoritarian, traditionalist society, protecting "traditional values" against assaults from social revolutionaries intent on overturning long-held moral values. It is certainly true that creationism is far more popular in the rural South, the Midwest, and the Southwest among supporters of the present Republican administration than among urban Northern Democrats. But the evolution/creation struggle has a complex history. Before World War II the science of evolution was virtually absent from school curricula everywhere in America, although explicit creationism was characteristic largely of the rural South and West. Then the atomic bomb and, later, an immense increase in the public funding of science as a response to the alarm raised by Sputnik resulted in a revolution in teaching science. With support from the National Science Foundation, evolution became a regular part of biology textbooks and science instruction in the public schools and remains so in most places.

In response, among those who had never lost their traditional fundamentalism, an active creationist reaction began, slowly accelerating to its present prominence. According to a series of polls taken over the last twenty-five years, about 50 percent of Americans believe that "God created man pretty much in his present form at one time within the last 10,000 years."[5] There have been repeated recent attempts in Minnesota, New Mexico, Ohio, Pennsylvania, Arkansas, and Kansas to make the study of challenges to evolutionary biology part of the mandated public school science curriculum. These have so far not succeeded, but Kansas seems on the verge of passing a statewide requirement that a new variant of the Creation myth, "intelligent design," be part of the discussion of evolution in public secondary schools. Intelligent design (ID) has itself been intelligently designed to circumvent legal challenges to the teaching of biblical creationism, challenges based on the constitutional requirement of a separation of church and state.

God, the Bible, and religion in general are not mentioned in the doctrine of ID. Rather, it is claimed that an objective examination of the facts of life makes it clear that organisms are too complex to have arisen by a process of the accumulation of naturally selected chance mutations and so must have been purposefully created by an unspecified intelligent designer. An alien from outer space? But the theory of ID is a transparent subterfuge. The problem is that if the living world is too complex to have arisen without an intelligent designer, then where did the intelligent designer come from? After all, she must have been as complex as the things she designed. If not, then we have evolution! Otherwise we must postulate an intelligent designer who designed the intelligent designer who..., back to the original one who must have been around forever. And who might that be? Like the ancient Hebrews the ID designers fear to pronounce Her name lest they be destroyed, but Her initials are clearly YWH.

The political identification of creationism with conservative politics is recent. Before World War II, rural populism in the Southwest and Midwest, motivated by resentment against politically and socially powerful Northern urban elites, included both creationism and socialism. In the election of 1912, the poorest rural counties of Texas and Oklahoma and Arkansas gave more votes to Eugene Debs than did the urban populations of Chicago and New York. At the same time the best-selling weekly in America was the Appeal to Reason, a socialist periodical published in Girard, Kansas. So, what's the matter with Kansas these days? The shift of American populism from the left to the right is part of the history of the disappearance of the American left as a serious political force.

We see then that Christian fundamentalists have been historically inconstant in their political preferences; and their demand for a public recognition of the literal truth of Genesis has not, at least so far, included agitation against the teachings of physical science. So the campaign against evolutionary biology must be neither an integral part of the politics of the right nor the consequence of a devotion in principle to a literal reading of the Bible. How then are we to explain the continued strength of the campaign against evolution? We can do no better than to listen to the Reverend Ron Carlson, a popular preacher, lecturer, and author. He presents to his audience two stories and asks them repeatedly whether it matters which one is true. In the secular story,

> you are the descendant of a tiny cell of primordial protoplasm washed up on an empty beach three and a half billion years ago. You are a mere grab-bag of atomic particles, a conglomeration of genetic substance. You exist on a tiny planet in a minute solar system... in an empty corner of a meaningless universe. You came from nothing and are going nowhere.

By contrast, the Christian view is that

> you are the special creation of a good and all-powerful God. You are the climax of His creation.... Not only is your kind unique, but you are unique among your kind.... Your Creator loves you so much and so intensely desires your companionship and affection that...He gave the life of His only Son that you might spend eternity with Him.[6]

What is at issue here is whether the experience of one's family, social, and working life, with its share of angst, pain, fatigue, and failure, can provide meaning in the absence of a belief in an ordained higher purpose. The continued appeal of a story of a divine creation of human life is that it provides, for those for whom the ordinary experience of living does not, a seductive relief from what Eric Fromm called the Anxiety of Meaninglessness. The rest is commentary.

3.

At the same time that religious forces have been attempting to destroy evolutionary biology by denying its truth, a movement within academia has been attempting to make Darwinism a universal model for an understanding of history and social dynamics. This movement has two roots in the traditions of intellectual life. In their intellectual formation, natural scientists have held up before them a model of scientific work that places a powerful value on general applicability and on inclusiveness. "Great" scientists are those who, like Newton, make laws that apply universally, while lesser ones spend their lives dissecting particular phenomena. If Darwinism is to satisfy the demand for generality then it must explain not only the evolution of the physical structure of the organism but of its individual and social behavior.

At the same time natural science has increasingly provided a source of academic legitimacy for inquiry that had previously been seen as a merely impressionistic endeavor. Surely there must be laws of history rather than just a narrative of one damned thing after another. Of course there is a long tradition of attempts to find laws of history. In his Muqaddimah, the fourteenth-century historian Ibn Khaldun formulated quantitative laws of "universal" (i.e., Arab) history and five hundred years later Hegel lamented that the problem for the historian was not to write history but to find a general theoretical frame on which the facts can be hung. More recently the study of history and social structures has often become "social science," with an apparatus of sample surveys and statistics. The searches for the general in the biological sciences and for legitimacy in explaining human social phenomena have converged in the creation of Darwinian models of human nature, of culture, and of history.

The first attempts at generalization, epitomized by E.O. Wilson's Sociobiology: the Modern Synthesis, were simple extensions of evolutionary theory within biology to nonphysical characters. A universal human nature was described, including such properties as religiosity, aggression, entrepreneurship, and conformity. Genes for these traits were postulated, and adaptive stories were invented to explain why they were established by natural selection. The credibility of these models was eventually undermined by the lack of evidence of genetic determination of such traits and by the slipperiness of attempts at trying to define the "universal" characteristics of human nature. So when I once pointed out to a sociobiologist that sane and rational human beings were willing to go to prison rather than engage in armed struggle, he replied that their resistance to the state was a form of aggression. One need not be an orthodox follower of Karl Popper to see that a theory that allows things to appear in the form of their apparent opposites when convenient is not of much value.

Naive sociobiology then gave way to evolutionary psychology, which avoids the danger of making predictions that are too specific and concerns itself with the evolution of underlying behavioral mechanisms of sexual attraction, fear of life-threatening circumstances, group cohesiveness, rationality, and so on. Such explanations, however, do not do the work that historians and sociologists require. For example, evolutionary psychology explains why babies emit piercing howls and wails when they are hungry or uncomfortable. They are helpless, and unless they can distract their parents from other concerns they will not be sure they will be fed or rescued from pain. Natural selection will then favor howling babies, since quiet ones may be malnourished or suffer injuries and so are less likely to survive.

Of course the screams of a baby can be counterproductive since parents have been known, in their frustration, to take drastic measures to quiet crying babies, even to the point of killing them. These are to be seen as pathological exceptions, however, when we take account of natural selection in favor of maternal love, since parents who injure their children will have fewer surviving offspring. While entirely plausible, such a theory does nothing to explain historical and social differences in child-rearing practices. As recently as the middle of the last century the administration of a swat on the buttocks or a rather energetic shaking was an entirely acceptable form of discipline for a recalcitrant child, but such behavior now is grounds for criminal charges of child abuse.

Evolutionary psychology also explains why all spoken languages must have certain phonemic properties in order that hearers can distinguish one word from another. The ability to distinguish similar spoken sounds is clearly of survival value. A confusion between "That animal always calls when cornered" and "That animal always kills when cornered" can lead to injury or death. What evolutionary psychology does not tell us, however, is why some people use clicks, some use rising and falling tones, why the kings of England finally came around to speaking English at home instead of French, or how the use of the periphrastic "do," as in the replacement of phrases like "I go not" by "I do not go," grew in the sixteenth and seventeenth centuries. Evolutionary psychology is not a theory applicable to historical change and cultural variation.

As a result, biological models of cultural change and diversity have been replaced by pseudobiological models, using the structure of Darwinian explanation metaphorically rather than literally. Darwinism is a population-based theory consisting of three claims. First, there is variation in some characteristics among individuals in a population. Second, that variation is heritable. That is, offspring tend to resemble their biological parents more than they do unrelated individuals. In modern Darwinism the mechanism of that inheritance is information about development that is contained in the genes that are passed from parent to offspring. Third, there are different survival and reproduction rates among individuals carrying different variants of a characteristic, depending on the environment inhabited by the carriers. That is the principle of natural selection. The consequence of differential reproduction of individuals with different inherited variants is that the population becomes richer over generations in some forms and poorer in others. The population evolves.

A classic case is the evolution of mimicry in butterflies. Some butterflies taste bad to their potential bird predators and the birds quickly learn from a few revolting trials to recognize them by their wing coloration and to avoid trying to eat them. Other species of butterflies that taste good have evolved wing patterns that make them look like the nasty-tasting species, and so are also avoided by their potential predators. This evolution was possible because butterfly wing patterns are genetically variable from individual to individual. In the past, an individual butterfly that tasted good and whose wings somewhat resembled those of the uneatable species would sometimes fool a bird and be spared from predation. The offspring of this survivor would on average resemble it. Some would be lucky enough to have combinations of genes from its two parents that resulted in its looking even more like the nasty species and their lives would be even more likely to be spared. The final result of these repeated generations of selection in favor of the mimics would be the evolution of an essentially perfect mimic.

Metaphorical Darwinian models of cultural and historical behavior do not contain genes, but contain cultural variants that arise like gene mutations and that are somehow differentially propagated over time in human minds and institutions, resulting in cultural evolution. The first, rather simple formulation of such a model in 1982 by Richard Dawkins[7] contains elementary particles of culture, memes, playing the role of genes, which are propagated to greater or lesser degrees because they are more or less appealing to people. The memes might be ways of pronouncing the letter r, or whether the color associated with death is white or black, or whether one prefers Luther to the Pope. In this model human beings are the carriers of the cultural particles, the physical propagators of these particles through communication, and they provide the environment that determines which memes are successful.

There have been a number of more or less complex variants on this original elementary metaphor for genetic evolution and it is generally agreed that the most nuanced and sophisticated version is contained in the work of Robert Boyd and Peter Richerson, and laid out in considerable detail in Not By Genes Alone. The title is meant to suggest that cultural evolution is not simply like, but is part of, the entirety of human evolutionary change. The authors begin by asserting, quite correctly, that culture is part of human biology partly because evolved neural structures that underlie psychological states must have some influence on what people believe and perceive and partly because the culture creates an environment in which future physical evolution by natural selection takes place. We could not have our present automotive culture without a certain minimum of depth perception. Moreover, since automobile accidents are the leading peacetime cause of death, by far, among people of reproductive age in technologically advanced countries (about one death per one hundred persons in this age group per generation in the United States), genes that favor short reaction time to perceived danger must be increasing in our population, slowly but inexorably.

Richerson and Boyd reject the simplistic model of gene-like "memes," but they are rather vague, as they must be, on how to recognize culture or its structure. They are aware that one aspect of culture will change in reaction to and in concert with other aspects of culture, that there is a complex network of causal dependency among parts of culture. Changes in technology, occupation, education, political attitudes, division of household labor and parental responsibility, leisure activities, and styles of speech and dress are connected as both causes and effects within and between generations.

The invention and spread of computers are the direct cause of major changes in patterns of education and leisure as books are replaced by on-line databases and computer games. They are the agents of the creation of new occupations and new methods of work, of changes in vocabulary and in volume and speed of interchange between individuals as well as the possibility that one person can communicate with large populations without the intervention and control of public media. They create the ability to purchase immediately a vast array of goods and services and to have access to a vast quantity of stored information.

All of these changes in turn feed back onto the development of further computer hardware and software, developments that amplify the effects already seen and create new forms of production, commerce, communication, and education. The difficulty that this complexity presents for making models of cultural change and diversification is that it has no clear structure. That structure has to be invented.

In Richerson and Boyd's formulation, cultural elements, ideas, tastes, languages, and attitudes are properties of individual human carriers who acquire them by a great variety of processes including conscious and unconscious imitation of others, direct teaching by parents, learning in formal educational settings, or by exposure to various forms of communication. Changes in frequency of cultural variants among specific populations occur by two basic mechanisms. First, there are biases in the transmission of cultural elements, some elements being more popular or easier to learn or simply more frequent among those from whom we acquire our culture. That might explain the spread of, for example, hard rock. Second, in a purely Darwinian mode, the carriers of some cultural variants may survive better or have more children. All other things being equal, the religious beliefs of those who oppose contraception on principle ought to be spreading like wildfire. The differential rate of reproduction and the biases in transmission are, of course, dependent on environment, but Boyd and Richerson recognize that the human environment is itself largely a consequence of culture so that cultural change is both the cause and effect of further evolution.

This model has some shortcomings. One is that much of one's culture is not acquired from other persons. When I walk down the street in Florence I do not have to hear anyone speak or read any sign to know that I am not anywhere in America. Buildings look strange, streets look strange, things have a strange smell, people carry their bodies in an unfamiliar way. I become conscious of a culture different from my own, a culture that I acquired throughout my development simply by walking down the street and being bombarded by sense impressions. Another is that no model of cultural evolution of which I am aware takes account of power. The people of Bavaria are predominantly Catholic while Westphalians are Protestant, not because somehow Lutheranism was more appealing to northerners but because at Augsburg in 1555 the warring German princes and the Holy Roman Emperor made peace using the rule of cuius regio, eius religio, which allowed rulers to enforce their own religion in their own dominions and to expel those who were recalcitrant.

The most important question is why we should use a Darwinian model at all for history and culture. The population model of variation, inheritance, and different rates of reproduction has been specifically designed to explain a particular set of natural phenomena that have a well-known empirical and mechanistic base. Even Darwin, who had no idea of genes or of the rules of inheritance, knew that organisms were reproduced only by other organisms, that offspring resembled their parents more in concrete physical characteristics than they resembled individuals not related to them, and that more organisms were reproduced than could survive to reproductive age. That was no guarantee that his model for evolution would have to be entirely correct because it might have turned out that there was significant inheritance of acquired characters.

Cultural evolutionists have no set of phenomena of comparable concreteness. They can't even reach an agreement on how to define and describe their objects of interest. The arguments offered by Boyd and Richerson for adopting a Darwinian model of cultural change are all epistemological: they serve an intellectual interest but cannot be said to accord better with the phenomena that they are meant to explain. They say of their arguments, for example, that "they provide islands of conceptual clarity in the midst of otherwise mind-numbing complexity and diversity"; that "they are productive of further work"; that they are "economical" of human intellectual labor; and that they will "increase the chance that we will detect useful generalizations in spite of the complexity and diversity of human behavior."

That a theoretical formulation is desirable because it makes it easier and more efficient to write more articles and books giving simple explanations for phenomena that are complex and diverse seems a strange justification for work that claims to be scientific. It confuses "understanding" in the weak sense of making coherent and comprehensible statements about the real world with "understanding" that means making correct statements about nature. It makes the investigation of material nature into an intellectual game, disarming us in our struggle to maintain science against mysticism. We would be much more likely to reach a correct theory of cultural change if the attempt to understand the history of human institutions on the cheap, by making analogies with organic evolution, were abandoned. What we need instead is the much more difficult effort to construct a theory of historical causation that flows directly from the phenomena to be explained. That the grand historical theorists of the past tried and failed to do this does not foreclose further efforts. After all, Darwin was preceded by eminent failures and even he did not get it all right.
Notes

[1] "Finding Design in Nature," The New York Times, July 7, 2005.

[2] "Qui sзait les races d'animaux qui nous ont prйcйdй? Qui sзait les races d'animaux qui succиderont aux nфtres? Tout change, tout passe, il n'y a que le tout qui reste." Le Rкve de d'Alembert.

[3] As compared to the book of an eminent anthropologist of the last generation, Earnest A. Hooten, Up from the Ape (Macmillan, 1946).

[4] Indeed, life on earth is about half over. It has been around for about two billion years and from our knowledge of the changes that occur in stars, the sun will become a "red giant" destroying the earth and other planets in another two billion years or so.

[5] Otis Dudley Duncan and Claudia Geist, "The Creationists: How Many, Who, and Where?" Reports of the National Center for Science Education, Vol. 24, No. 5 (September–October 2004), pp. 26–33.

[6] Ron Carlson and Ed Decker, Fast Facts on False Teachings (Harvest House, 2003).

[7] Richard Dawkins, The Extended Phenotype: The Gene as the Unit of Selection (Freeman, 1982).

Stephen Jay Gould—
What Does it Mean to Be a Radical?

by Richard C. Lewontin and Richard Levins

Early this year, Stephen Gould developed lung cancer, which spread so quickly that there was no hope of survival. He died on May 20, 2002, at the age of sixty. Twenty years ago, he had escaped death from mesothelioma, induced, we all supposed, by some exposure to asbestos. Although his cure was complete, he never lost the consciousness of his mortality and gave the impression, at least to his friends, of an almost cheerful acceptance of the inevitable. Having survived one cancer that was probably the consequence of an environmental poison, he succumbed to another.

The public intellectual and political life of Steve Gould was extraordinary, if not unique. First, he was an evolutionary biologist and historian of science whose intellectual work had a major impact on our views of the process of evolution. Second, he was, by far, the most widely known and influential expositor of science who has ever written for a lay public. Third, he was a consistent political activist in support of socialism and in opposition to all forms of colonialism and oppression. The figure he most closely resembled in these respects was the British biologist of the 1930's, J. B. S. Haldane, a founder of the modern genetical theory of evolution, a wonderful essayist on science for the general public, and an idiosyncratic Marxist and columnist for the *Daily Worker* who finally split with the Communist Party over its demand that scientific claims follow Party doctrine.

What characterizes Steve Gould's work is its consistent radicalism. The word *radical* has come to be synonymous with *extreme* in everyday usage: *Monthly Review* is a *radical* journal to the readers of the *Progressive*; Steve Gould underwent *radical* surgery when tumors were removed from his brain; and a *radical* is someone who is out in left (or right) field. But a brief excursion into the *Oxford English Dictionary* reminds us that the root of the word radical is, in fact, *radix*, the Latin word for *root.* To be radical is to consider things from their very root, to go back to square one, to try to reconstitute one's actions and ideas by building them from first principles. The impulse to be radical is the impulse to ask, "How do I know that?" and, "Why am I following this course rather than another?" Steve Gould had that radical impulse and he followed it where it counted.

First, Steve was a radical in his science. His best-known contribution to evolutionary biology was the theory of *punctuated equilibrium* that he developed with his colleague Niles Eldridge. The standard theory of the change in the shape of organisms over evolutionary time is that it occurs constantly, slowly, and gradually with more or less equal changes happening in equal time intervals. This seems to be the view that Darwin had, although almost anything can be read from Darwin's nineteenth century prose. Modern genetics has shown that any heritable change in development that is at all likely to survive will cause only a slight change in the organism, that such mutations occur at a fairly constant rate over long time periods and that the force of natural selection for such small changes is also of small magnitude. These facts all point to a more or less constant and slow change in species over long periods.

When one looks at the fossil record, however, observed changes are much more irregular. There are more or less abrupt changes in shape between fossils that succeed each other in geological time with not much evidence for the supposed gradual intermediates between them. The usual explanation is that fossils are relatively rare and we are only seeing occasional snapshots of the actual progression of organisms. This is a perfectly coherent theory, but Eldridge and Gould went back to square one, and questioned whether the rate of change under natural selection was really as constant as everybody assumed. By examining a few fossil series in which there was a much more complete temporal record than is usual, they found evidence of long periods of virtually no change punctuated by short periods during which most of the change in shape appeared to occur. They generalized this finding into a theory that evolution occurs in fits and starts and provided several possible explanations, including that much of evolution occurred after sudden major changes in environment. Steve Gould went even further in his emphasis on the importance of major irregular events in the history of life. He placed great importance on sudden mass extinction of species after collisions of large comets with the Earth and the subsequent repopulation of the living world from a restricted pool of surviving species. The temptation to see some simple connection between Steve's theory of episodic evolution and his adherence to Marx's theory of historical stages should be resisted. The connection is much deeper. It lies in his radicalism.

Another aspect of Gould's radicalism in science was in the form of his general approach to evolutionary explanation. Most biologists concerned with the history of life and its present geographical and ecological distribution assume that natural selection is the cause of all features of living and extinct organisms and that the task of the biologist, insofar as it is to provide explanations, is to come up with a reasonable story of why any particular feature of a species was favored by natural selection. If, when the human species lost most of its body hair in evolving from its ape-like ancestor, it still held on to eyebrows, then eyebrows must be good things. A great emphasis of Steve's scientific writing was to reject this simplistic Panglossian adaptationism, and to go back to the variety of fundamental biological processes in the search for the causes of evolutionary change. He argued that evolution was a result of random as well as selective forces and that characteristics may be the physical byproducts of selection for other traits. He also argued strongly for the historical contingency of evolutionary change. Something may be selected for some reason at one time and then for an entirely different reason at another time, so that the end product is the result of the whole history of an evolutionary line, and cannot be accounted for by its present adaptive significance. Thus, for instance, humans are the way we are because land vertebrates reduced many fin patterns to four limbs, mammals' hearts happen to lean to the left while birds' hearts lean to the right, the bones of the inner ear were part of the jaw of our reptilian ancestors, and it just happened to get dry in east Africa at a crucial time in our evolutionary history. Therefore, if intelligent life should ever visit us from elsewhere in the universe, we should not expect them to have a human shape, suffer from sexist hierarchy, or have a command deck on their space ship.

Gould also emphasized the importance of developmental relations between different parts of an organism. A famous case was his study of the Irish elk, a very large extinct deer with enormous antlers, much greater in proportion to the animal's size than is seen in modern deer. The invented adaptationist story was that male deer antlers are under constant natural selection to increase in size because males use them in combat when they compete for access to females. The Irish elk pushed the evolution of this form of machismo too far and their antlers became so unwieldy that they could not carry on the normal business of life and so became extinct. What Steve showed was that for deer in general, species with larger body size have antlers that are more than proportionately larger, a consequence of a differential growth rate of body size and antler size during development. In fact, Irish elk had antlers of exactly the size one would predict from their body size and no special story of natural selection is required.

None of Gould's arguments about the complexity of evolution overthrows Darwin. There are no new paradigms, but perfectly respectable "normal science" that adds richness to Darwin's original scheme. They typify his radical rule for explanation: always go back to basic biological processes and see where that takes you.

Steve Gould's greatest fame was not as a biologist but as an explicator of science for a lay public, in lectures, essays, and books. The relation between scientific knowledge and social action is a problematic one. Scientific knowledge is an esoteric knowledge, possessed and understood by a small elite, yet the use and control of that knowledge by private and public powers is of great social consequence to all. How is there to be even a semblance of a democratic state when vital knowledge is in the hands of a self-interested few? The glib answer offered is that there are instruments of the popularization of science, chiefly science journalism and the popular writings of scientists, which create an informed public. But that popularization is itself usually an instrument of obfuscation and the pressing of elite agendas.

Science journalists suffer from a double disability: First, no matter how well educated, intelligent, and well-motivated, they must, in the end, trust what scientists tell them. Even a biologist must trust what a physicist says about quantum mechanics. A large fraction of science reporting begins with a press conference or release produced by a scientific institution. "Scientists at the Blackleg Institute announced today the discovery of the gene for susceptibility to repetitive motion injury." Second, the media for which science reporters work put immense pressure on them to write dramatic accounts. Where is the editor who will allot precious column inches to an article about science whose message is that it is all very complicated, that no predictions can be made, that there are serious experimental difficulties in the way of finding the truth of the matter, and that we may never know the answer? Third, the esoteric nature of scientific knowledge places almost insuperable rhetorical barriers between even the most knowledgeable journalist and the reader. It is not generally realized that a transparent explanation in terms accessible to the lay reader requires the deepest possible knowledge of the matter on the part of the writer.

Scientists, and their biographers, who write books for a lay public are usually concerned to press uncritically the romance of the intellectual life, the wonders of their science, and to propagandize for yet greater support of their work. Where is the heart so hardened that it cannot be captivated by Stephen Hawking and his intellectual enterprise? Even when the intention is simply to inform a lay public about a body of scientific knowledge, the complications of the actual state of understanding are so great that the pressure to tell a simple and appealing story is irresistible.

Steve Gould was an exception. His three hundred essays on scientific questions, published in his monthly column in *Natural History Magazine*, many of which were widely distributed in book form, combined a truthful and subtle explication of scientific findings and problems, with a technique of exposition that neither condescended to his readers nor oversimplified the science. He told the complex truth in a way that his lay readers could understand, while enlivening his prose with references to baseball, choral music, and church architecture. Of course, when we consider writing for a popular audience, we have to be clear about what we mean by *popular.* The Uruguayan writer Eduardo Galeano asked what we mean by writing for "the people" when most of our people are illiterate. In the North there is less formal illiteracy, but Gould wrote for a highly educated, even if nonspecialist, audience for whom choral music and church architecture provided more meaningful metaphors than the scientific ideas themselves.

Most of the subjects Steve dealt with were meant to be illustrative precisely of the complexity and diversity of the processes and products of evolution. Despite the immense diversity of matters on which he wrote there was, underneath, a unifying theme: that the complexity of the living world cannot be treated as a manifestation of some grand general principle, but that each case must be understood by examining it from the ground up and as the realization of one out of many material paths of causation.

In his political life Steve was part of the general movement of the left. He was active in the anti-Vietnam War movement, in the work of Science for the People, and of the New York Marxist School. He identified himself as a Marxist but, like Darwinism, it is never quite certain what that identification implies. Despite our close comradeship in many things over many years, we never had a discussion of Marx's theory of history or of political economy. More to the point, however, by insisting on his adherence to a Marxist viewpoint, he took the opportunity offered to him by his immense fame and legitimacy as a public intellectual to make a broad public think again about the validity of a Marxist analysis.

At the level of actual political struggles, his most important activities were in the fight against creationism and in the campaign to destroy the legitimacy of biological determinism including sociobiology and racism. He argued before the Arkansas State Legislature that differences among evolutionists or unsolved evolutionary problems do not undermine the demonstration of evolution as an organizing principle for understanding life. He was one of the authors of the original manifesto challenging the claim of sociobiology that there is an evolutionarily derived and hard-wired human nature that guarantees the perpetuation of war, racism, the inequality of the sexes, and entrepreneurial capitalism. He continued throughout his career to attack this ideology and show the shallowness of its supposed roots in genetics and evolution. His most significant contribution to the delegitimation of biological determinism, however, was his widely read exposure of the racism and dishonesty of prominent scientists, *The Mismeasure of Man*. Here again, Gould showed the value of going back to square one.

Not content simply to show the evident class prejudice and racism expressed by American, English, and European biologists, anthropologists, and psychologists prior to the Second World War, he actually examined the primary data on which they based their claims of the larger brains and superior minds of northern Europeans. In every case the samples had been deliberately biased, or the data misrepresented, or even invented, or the conclusions misstated. The consistently fraudulent data on IQ produced by Cyril Burt had already been exposed by Leo Kamin, but this might have been dismissed as unique pathology in an otherwise healthy body of inquiry. The evidence produced by Steve Gould of pervasive data cooking by an array of prominent investigators made it clear that Burt was not aberrant, but typical. It is widely agreed that ideological commitments may have an unconscious effect on the directions and conclusions of scientists. But generalized deliberate fraud in the interests of a social agenda? What more radical attack on the institutions of "objective" science could one imagine?

Being a radical in the sense that informs this memorial is not easy because it involves a constant questioning of the bases of claims and actions, not only of others, but also of our own. No one, not even Steve Gould, could claim to succeed in being consistently radical, but, as Rabbi Tarfon wrote, "It is not incumbent on us to succeed, but neither are we free to refrain from the struggle."

Darwinism defined   the difference between fact and theory

essay

Stephen Jay Gould

http://www.findarticles.com/p/articles/mi_m1511/is_v8/ai_4665760

Charles Darwin, who was, perhaps, the most incisive thinker amongthe great minds of history, clearly divided his life's work into two claims of different character: establishing the fact of evolution, and proposing a theory (natural selection) for the mechanism of evolutionary change. He also expressed, and with equal clarity, his judgment about their different status: confidence in the facts of transmutation and genealogical connection among all organisms, and appropriate caution about his unproved theory of natural selection. He stated in the Descent of Man: "I had two distinct objects in view; firstly, to show that species had not been separately created, and secondly, that natural selection had been the chief agent of change . . . If I have erred in . . . having exaggerated its [natural selection's] power . . . I have at least, as I hope, done good service in aiding to overthrow the dogma of separate creations."

Darwin wrote those words more than a century ago. Evolutionary biologists have honored his fundamental distinction between fact and theory ever since. Facts are the world's data; theories are explanations proposed to interpret and coordinate facts. The fact of evolution is as well established as anything in science (as secure as the revolution of the earth about the sun), though absolute certainty has no place in our lexicon. Theories, or statements about the causes of documented evolutionary change, are now in a period of intense debate -- a good mark of science in its healthiest state. Facts don't disappear while scientists debate theories. As I wrote in an early issue of this magazine (May 1981), "Einstein's theory of gravitation replaced Newton's, but apples did not suspend themselves in mid-air pending the outcome."

Since facts and theories are so different, it isn't surprising that these two components of science have had separate histories ever since Darwin. Between 1859 (the year of publication for the Origin of Species) and 1882 (the year of Darwin's death), nearly all thinking people came to accept the fact of evolution. Darwin lies beside Newton in Westminster Abbey for this great contri- bution. His theory of natural selection has experienced a much different, and checkered, history. It attracted some notable followers during his lifetime (Wallace in England, Weismann in Germany), but never enjoyed majority support. It became an orthodoxy among English-speaking evolutionists (but never, to this day, in France or Germany) during the 1930s, and received little cogent criticism until the 1970s. The past fifteen years have witnessed a revival of intense and, this time, highly fruitful debate as scientists discover and consider the implications of phenomena that expand the potential causes of evolution well beyond the unitary focus of strict Darwinism (the struggle for reproductive success among organisms within populations). Darwinian selection will not be overthrown; it will remain a central focus of more inclusive evolutionary theories. But new findings and interpretations at all levels, from molecular change in genes to patterns of overall diversity in geological time, have greatly expanded the scope of important causes -- from random, selectively neutral change at the genetic level, to punctuated equilibria and catastrophic mass extinction in geological time.

In this period of vigorous pluralism and intense debate among evolutionary biologists, I am greatly saddened to note that some distinguished commentators among non-scientists, in particular Irving Kristol in a New York Times Op Ed piece of Sept. 30, 1986 ("Room for Darwin and the Bible"), so egregiously misunderstand the character of our discipline and continue to confuse this central distinction between secure fact and healthy debate about theory.

I don't speak of the militant fundamentalists who label themselves with the oxymoron "scientific creationists," and try to sneak their Genesis literalism into high school classrooms under the guise of scientific dissent. I'm used to their rhetoric, their dishonest mis- and half-quotations, their constant repetition of "useful" arguments that even they must recognize as nonsense (disproved human footprints on dinosaur trackways in Texas, risible misinterpretation of thermodynamics to argue that life's complexity couldn't increase without a divine boost). Our strug- gle with these ideologues is political, not intellectual. I speak instead of our allies among people committed to reason and honorable argument.

Kristol, who is no fundamentalist, accuses evolutionary biologists of bringing their troubles with creationists upon themselves by too zealous an insistence upon the truths of Darwin's world. He writes: ". . . the debate has become a dogmatic crusade on both sides, and our educators, school administrators, and textbook publishers find themselves trapped in the middle." He places the primary blame upon a supposedly anti-religious stance in biological textbooks: "There is no doubt that most of ur textbooks are still written as participants in the 'warfare' between sci- ence and religion that is our heritage from the 19th century. And there is also little doubt that it is this pseudoscientific dogmatism that has provoked the current religious reaction."

Kristol needs a history lesson if he thinks that current creationism is a product of scientific intransigence. Creationism, as a political movement against evolution, has been a continually pow- erful force since the days of the Scopes trial. Rather than using evolution to crusade against religion in their texts, scientists have been lucky to get anything at all about evolution into books for high school students ever since Scopes's trial in 1925. My own high school biology text, used in the liberal constituency of New York City in 1956, didn't even mention the word evolution. The laws that were used against Scopes and cowed textbook publishers into submission weren't overturned by the Supreme Court until 1968 (Epperson v. Arkansas).

But what about Kristol's major charge -- anti-religious prejudice and one-dimensional dogmatism about evolution in modern textbooks? Now we come to the heart of what makes me so sad about Kristol's charges and others in a similar vein. I don't deny that some texts have simplified, even distorted, in failing to cover the spectrum of modern debates; this, I fear, is a limitation of the genre itself (and the reason why I, though more of a writer than most scientists, have never chosen to compose a text). But what evidence can Kristol or anyone else provide to demonstrate that evolutionists have been worse than scientists from other fields in glossing over legitimate debate within their textbooks?

Consider the evidence. Two textbooks of evolution now dominate the field. One has as its senior author Theodosius Dob zhansky, the greatest evolutionist of our century, and a lifelong Russian Orthodox; nothing anti-religious could slip past his watchful eye. The second, by Douglas Futuyma, is a fine book by a kind and generous man who could never be dogmatic about anything except intolerance. (His book gives a fair hearing to my own heterodoxies, while dissenting from them.)

When we come to popular writing about evolution, I suppose that my own essays are as well read as any. I don't think that Kristol could include me among Darwinian dogmatists, for most of my essays focus upon my disagreements with the strict version of natural selection. I also doubt that Kristol would judge me anti- religious, since I have campaigned long and hard against the same silly dichotomy of science versus religion that he so rightly ridicules. I have written laudatory essays about several scientists (Burnet, Cuvier, Buckland, and Gosse, among others) branded as theological dogmatists during the nineteenth-century reaction; and, while I'm not a conventional believer, I don't consider myself irreligious.

Kristol's major error lies in his persistent confusion of fact with theory. He accuses us -- without giving a single concrete example, by the way -- of dogmatism about theory and sustains his charge by citing our confidence in the fact of transmutation. "It is reasonable to suppose that if evolution were taught more cautiously, as a conglomerate idea consisting of conflicting hypothe- ses rather than as an unchallengeable certainty, it would be far less controversial."

Well, Mr. Kristol, evolution (as theory) is indeed "a conglomerate idea consisting of conflicting hypotheses," and I and my colleagues teach it as such. But evolution is also a fact of nature, and so do we teach it as well, just as our geological colleagues describe the structure of silicate minerals, and astronomers the elliptical orbits of planets.

Rather than castigate Mr. Kristol any further, I want to discussthe larger issue that underlies both this incident and the popular perception of evolution in general. If you will accept my premise that evolution is as well established as any scientific fact (I shall give the reasons in a moment), then why are we uniquely called upon to justify our chosen profession; and why are we alone subjected to such unwarranted infamy? To this central question of this essay, I suggest the following answer. We haven't received our due for two reasons: (1) a general misunderstanding of the different methods used by all historical sciences (including evolution), for our modes of inference don't match stereotypes of "the scientific method"; and (2) a continuing but unjustified fear about the implication both of evolution itself and of Darwin's theory for its mechanism. With these two issues resolved, we can understand both the richness of science (in its pluralistic methods of inquiry) and the absence of any conflict, through lack of common content, between proper science and true religion.

Our confidence in the fact of evolution rests upon copious data that fall, roughly, into three great classes. First, we have the direct evidence of small-scale changes in controlled laboratory experiments of the past hundred years (on bacteria, on almost every measurable property of the fruit fly Drosophila), or observed in nature (color changes in moth wings, development of metal tolerance in plants growing near industrial waste heaps), or produced during a few thousand years of human breeding and agriculture. Creationists can scarcely ignore this evidence, so they respond by arguing that God permits limited modification within created types, but that you can never change a cat into a dog (who ever said that you could, or that nature did?).

Second, we have direct evidence for large-scale changes, based upon sequences in the fossil record. The nature of this evidence is often misunderstood by non-professionals who view evolution as a simple ladder of progress, and therefore expect a linear array of "missing links." But evolution is a copiously branching bush, not a ladder. Since our fossil record is so imperfect, we can't hope to find evidence for every tiny twiglet. (Sometimes, in rapidly evolving lineages of abundant organisms restricted to a small area and entombed in sediments with an excellent fossil record, we do discover an entire little bush -- but such examples are as rare as they are precious.) In the usual case, we may recover the remains of side branch number 5 from the bush's early history, then bough number 40 a bit later, then the full series of branches 156-161 in a well preserved sequence of younger rocks, and finally surviving twigs 250 and 287.

In other words, we usually find sequences of structural intermediates, not linear arrays of ancestors and descendants. Such sequences provide superb examples of temporally ordered evo- lutionary trends. Consider the evidence for human evolution in Africa. What more could you ask from a record of rare creatures living in terrestrial environments that provide poor opportunity for fossilization? We have a temporal sequence displaying clear trends in a suite of features, including threefold increase of brain size and corresponding decrease of jaws and teeth. (We are missing direct evidence for an earlier transition to upright posture, but wide-ranging and unstudied sediments of the right age have been found in East Africa, and we have an excellent chance to fill in this part of our story.) What alternative can we suggest to evolution? Would God -- for some inscrutable reason, or merely t test our faith -- create five species, one after the other (Australopithecus afarensis, A. africanus, Homo habilis, H. erectus, and H. sapiens), to mimic a continuous trend of evolutionary change?

Or, consider another example with evidence of structurally intermediate stages -- the transition from reptiles to mammals. The lower jaw of mammals contains but a single bone, the dentary. Reptiles build their lower jaws of several bones. In perhaps the most fascinating of those quirky changes in function that mark pathways of evolution, the two bones articulating the upper and lower jaws of reptiles migrate to the middle ear and become the malleus and incus (hammer and anvil) of mammals.

Creationists, ignorant of hard evi dence in the fossil record, scoff at this tale. How could jaw bones become ear bones, they ask. What happened in between? An animal can't work with a jaw half disarticulated during the stressful time of transition.

The fossil record provides a direct answer. In an excellent series of temporally ordered structural intermediates, the reptilian dentary gets larger and larger, pushing back as the other bones of a reptile's lower jaw decrease in size. We've even found a transitional form with an elegant solution to the problem of remaking jaw bones into ear bones. This creature has a double articulation -- one between the two bones that become the mammalian hammer and anvil (the old reptilian joint), and a second between the squamosal and dentary bones (the modern mammalian condi- tion). With this built-in redundancy, the emerging mammals could abandon one connection by moving two bones into the ear, while retaining the second linkage, which becomes the sole articulation of modern mammals.

Third, and most persuasive in its ubiquity, we have the signs ofhistory preserved within every organism, every ecosystem, and every pattern of biogeographic distribution, by those pervasive quirks, oddities, and imperfections that record pathways of historical descent. These evidences are indirect, since we are viewing modern results, not the processes that caused them, but what else can we make of the pervasive pattern? Why does our body, from the bones of our back to the musculature of our belly, display the vestiges of an arrangement better suited for quadrupedal life if we aren't the descendants of four-footed creatures? Why do the plants and animals of the Galapagos so closely resemble, but differ slightly from, the creatures of Ecuador, the nearest bit of land 600 miles to the east, especially when cool oceanic currents and volcanic substrate make the Galapagos such a different environment from Ecuador (thus removing the potential argument that God makes the best creatures for each place, and small differences only reflect a minimal disparity of environments)? The similarities can only mean that Ecuadorian creatures colonized the Galapagos and then diverged by a natural process of evolution.

This method of searching for oddities as vestiges of the past isn't peculiar to evolution, but a common procedure of all historical science. How, for example, do we know that words have histories, and haven't been decreed by some all-knowing committee in Mr. Orwell's bureau of New-speak? Doesn't the bucolic etymology of so many words testify to a different life style among our ancestors? In this article, I try to "broadcast" some ideas (a mode of sowing seed) in order to counter the most "egregious" of creationist sophistries (the animal ex grege, or outside the flock), for which, given the quid pro quo of business, this fine magazine pays me an "emolument" (the fee that millers once received to grind corn).

I don't want to sound like a shrill dogmatist shouting "rally round the flag boys," but biologists have reached a consensus, based on these kinds of data, about the fact of evolution. When honest critics like Irving Kristol misinterpret this agreement, they're either confusing our fruitful consonance about the fact of evolution with our vibrant dissonance about mechanisms of change, or they've misinterpreted part of our admittedly arcane technical literature.

One such misinterpretation has gained sufficient notoriety in the last year that we crave resolution both for its own sake and as an illustration of the frustrating confusion that can arise when scientists aren't clear and when commentators, as a result of hidden agendas, don't listen. Tom Bethell argued in Harper's (February 1985) that a group of young taxonomists called pattern cladists have begun to doubt the existence of evolution itself.

This would be truly astounding news, since cladistics is a powerful method dedicated to reforming classification by using only the branching order of lineages on evolutionary trees ("propinquity of descent" in Darwin's lovely phrase), rather than vague notions of overall similarity in form or function. (For example, in the cladistic system, a lungfish is more closely related to a horse than to a salmon because the common ancestor of lungfish and horse is more recent in time than the link point of the lungfish-horse lineage with the branch leading to modern bony fishes (including salmon).

Cladists use only the order of branching to construct their schemes of relationships; it bothers them not a whit that lungfish and salmon look and work so much alike. Cladism, in other words, is the purest of all genealogical systems for classification, since it works only with closeness of common ancestry in time. How preciously ironic then, that this most rigidly evolutionary of all taxonomic systems should become the subject of such extraordinary misunderstanding -- as devised by Bethell, and perpetuated by Kristol when he writes: ". . . many younger biologists (the so- called 'cladists') are persuaded that the differences among species -- including those that seem to be closely related -- are such as to make the very concept of evolution questionable."

This error arose for the following reason. A small splinter group of cladists (not all of them, as Kristol claims) -- "transformed" or "pattern" cladists by their own designation -- have adopted what is to me an ill-conceived definition of scientific procedure. They've decided, by misreading Karl Popper's philosophy, that patterns of branching can be established unambiguously as a fact of nature, but that processes causing events of branching, since they can't be observed directly, can't be known with certainty. Therefore, they say, we must talk only of pattern and rigidly exclude all discussion of process (hence "pattern cladistics").

This is where Bethell got everything arse-backwards and began the whole confusion. A philosophical choice to abjure all talk about process isn't the same thing as declaring that no reason for patterns of branching exists. Pattern cladists don't doubt that evolution is the cause behind branching; rather, they've decided that our science shouldn't be discussing causes at all.

Now I happen to think that this philosophy is misguided; in unguarded moments I would even deem it absurd. Science, after all, is fundamentally about process; learning why and how things happen is the soul of our discipline. You can't abandon the search for cause in favor of a dry documentation of pattern. You must take risks of uncertainty in order to probe the deeper questions, rather than stopping with sterile ecurity. You see, now I've blown our cover. We scientists do have our passionate debates -- and I've just poured forth an example. But as I wrote earlier, this is a debate about the proper approach to causes, not an argument about whether causes exist, or even whether the cause of branching is evolution or something else. No cladist denies that branching patterns arise by evolution.

This incident also raises the troubling issue of how myths become beliefs through adulterated repetition without proper documentation. Bethell began by misunderstanding pattern cladistics, but at least he reports the movement as a small splinter, and tries to reproduce their arguments. Then Kristol picks up the ball and recasts it as a single sentence of supposed fact -- and all cladists have now become doubters of evolution by proclamation. Thus a movement, by fiat, is turned into its opposite -- as the purest of all methods for establishing genealogical connections becomes a weapon for denying the mechanism that all biologists accept as the cause of branching on life's tree: evolution itself. Our genealogy hasn't been threatened, but my geniality has almost succumbed.

When I ask myself why the evidence for evolution, so clear to all historical scientists, fails to impress intelligent nonscientists, I must believe that more than simple misinformation lies at the root of our difficulty with a man like Irving Kristol. I believe that the main problem centers upon a restrictive stereotype of scientific method accepted by most non-practitioners as the essential definition of all scientific work.

We learn in high school about the scientific method -- a cut- and-dried procedure of simplification to essential components, experiment in the controlled situation of a laboratory, prediction and replication. But the sciences of history -- not just evolution but a suite of fundamental disciplines ranging from geology, to cosmology, to linguistics -- can't operate by this stereotype. We are charged with explaining events of extraordinary complexity that occur but once in all their details. We try to understand the past, but don't pretend to predict the future. We can't see past processes directly, but learn to infer their operation from preserved results.

Science is a pluralistic enterprise with a rich panoply of methods appropriate for different kinds of problems. Past events of long duration don't lie outside the realm of science because we cannot make them happen in a month within our laboratory. Direct vision isn't the only, or even the usual, method of inference in science. We don't see electrons, or quarks, or chemical bonds, any more than we see small dinosaurs evolve into birds, or India crash into Asia to raise the Himalayas.

William Whewell, the great English philosopher of science duringthe early nineteenth century, argued that historical science can reach conclusions, as well confirmed as any derived from experiment and replication in laboratories, by a method he called "consilience" (literally "jumping together") of inductions. Since we can't see the past directly or manipulate its events, we must use the different tactic of meeting history's richness head on. We must gather its won- drously varied results and search for a coordinating cause that can make sense of disparate data otherwise isolated and uncoordinated. We must see if a set of results so diverse that no one had ever considered their potential coordination might jump together as the varied products of a single process. Thus plate tectonics can explain magnetic stripes on the sea floor, the rise and later erosion of the Appalachians, the earthquakes of Lisbon and San Francisco, the eruption of Mount St. Helens, the presence of large flightless ground birds only on continents once united as Gondwanaland, and the discovery of fossil coal in Antarctica.

Darwin, who understood the different rigor of historical scienceso well, complained bitterly about those critics who denied scientific status to evolution because they couldn't see it directly or reproduce its historical results in a laboratory. He wrote to Hooker in 1861: "Change of species cannot be directly proved . . . The doctrine must sink or swim according as it groups and explains phenomena. It is really curious how few judge it in this way, which is clearly the right way." And later, in 1868: "This hypothesis may be tested . . . by trying whether it explains several large and independent classes of facts; such as the geological succession of organic beings, their distribution in past and present times, and their mutual affinities and homologies."

If a misunderstanding of the different methods of historical inquiry has impeded the recognition of evolution as a product of science at its best, then a residual fear for our own estate has continued to foster resentment of the fact that our physical bodies have ancient roots in ape-like primates, waddling reptiles, jawless fishes, worm-like invertebrates, and other creatures deemed even lower or more ignoble. Our ancient hopes for human transcendence have yet to make their peace with Darwin's world.

But what challenge can the facts of nature pose to our own decisions about the moral value of our lives? We are what we are, but we interpret the meaning of our heritage as we choose. Science can no more answer the questions of how we ought to live than religion can decree the age of the earth. Honorable and discerning scientists (most of us, I trust) have always understood that the limits to what science can answer also describe the power of its methods in their proper domain. Darwin himself exclaimed that science couldn't touch the problem of evil and similar moral conun- drums: "A dog might as well speculate on the mind of Newton. Let each man hope and believe what he can."

There is no warfare between science and religion, never was except as a historical vestige of shifting taxonomic boundaries among disciplines. Theologians haven't been troubled by the fact of evolution, unless they try to extend their own domain beyond its proper border (hubris and territorial expansionism aren't the sins of scientists alone, despite Mr. Kristol's fears). The Reverend Henry Ward Beecher, our greatest orator during Darwin's century, evoked the most quintessential of American metaphors in dismissing the entire subject of conflict between science and religion with a single epithet: "Design by wholesale is grander

than design by retail" --or, general laws rather than creation of each item by fiat will satisfy our notion of divinity.

Similarly, most scientists show no hostility to religion. Why should we, since our subject doesn't intersect the concerns of theology? I strongly dispute Kristol's claim that "the current teaching of evolution in our public schools does indeed have an ideological bias against religious belief." Unless at least half my colleagues are inconsistent dunces, there can be -- on the most raw and direct empirical grounds -- no conflict between science and religion. I know hundreds of scientists who share a conviction about the fact of evolution, and teach it in much the same way. Among these people I note an entire spectrum of religious attitudes -- from devout daily prayer and worship to resolute atheism. Either there's no correlation between religious belief and confidence in evolution -- or else half these peple are fools.

The common goal of science and religion is our shared struggle for wisdom in all its various guises. I know no better illustration of this great unity than a final story about Charles Darwin. This scourge of fundamentalism had a conventional church burial -- in Westminster Abbey no less. J. Frederick Bridge, Abbey organist and Oxford don, composed a funeral anthem expecially for the occasion. It may not rank high in the history of music, but it is, as my chorus director opined, a "sweet piece." (I've made what may be the only extant recording of this work, marred only by the voice of yours truly within the bass section.) Bridge selected for his text the finest biblical description of the common aim that will forever motivate both the directors of his building and the inhabitants of the temple of science -- wisdom. "Her ways are ways of pleasantness and all her paths are peace" (Proverbs 3:17).

I am only sorry that Dr. Bridge didn't set the very next metaphor about wisdom (Proverbs 3:18), for it describes, with the proper topology of evolution itself, the greatest dream of those who followed the God of Abraham, Isaac, and Jacob: "She is a tree of life to them that lay hold upon her."

To See or Not to See: Evolution of Eye Degeneration in Mexican Blind Cavefish1

Jeffery, William R

INTRODUCTION

In 1872 Charles Darwin wrote, "As it is difficult to imagine that eyes, though useless, could in any way be injurious to animals living in darkness, I attribute their loss solely to disuse." This statement launched more than a hundred years of speculation and debate on the evolutionary mechanisms responsible for the loss of eyes in cave animals (Culver, 1982). Today this problem is still unresolved, but prevailing opinions usually support one of two hypotheses.

The neutral mutation hypothesis suggests that eye degeneration is caused by random mutations in eye forming genes, which gradually accumulate in the absence of selective pressure. In contrast, the adaptation hypothesis suggests that natural selection causes the loss of eyes due to advantages in losing eyesight. As exclaimed in Darwin's famous quotation, the actual benefits of blindness are uncertain. Thus, different versions of the adaptation hypothesis have attributed the loss of eyesight to energy conservation, citing the high cost of making an eye, or to enhancement of other sensory organs that are highly beneficial to survival in the cave environment. Through the years, however, little or no experimental verification has been leveled in support of any version of either hypothesis. To understand the evolution of eye degeneration, it is necessary to determine the molecular and cellular mechanisms of the degenerative process, and whether the same or different genes and mechanisms are involved in loss of vision.

We study the mechanisms of visual degeneration in the Mexican Tetra, Astyanax mexicanus, a single species consisting of a surface-dwelling form (surface fish) (Fig. IA) and many cave dwelling (cavefish) forms inhabiting different caves (Fig. IB-E) (Jeffery, 2001). The Mexican tetra is easy to raise in the laboratory and exhibits many of the attributes that have made zebrafish a popular model system in developmental biology. These features include external fertilization, frequent and abundant spawning, transparent embryos, a 4-6 month generation time, and the opportunity for molecular, developmental, and genetic analysis. The surface and cave forms of A. mexicanus are interfertile, and successful mating is also possible between different cavefish populations (Sadoglu, 1957; Wilkens, 1971). Because of these attributes Astyanax cavefish represent one of the few cave animals in which laboratory experiments can be conducted on the mechanisms of eye degeneration and these mechanisms can be compared in the same species from different caves. Here we review current progress on the evolution and development of Astyanax cavefish and discuss how these studies have contributed to understanding the evolutionary basis of eye degeneration.

CAVEFISH EVOLUTIONARY HISTORY

To evaluate differences or similarities in the mechanisms of eye degeneration, it is first necessary to understand the evolutionary history of cavefish populations. Did all cavefish populations originate from a common ancestor and lose their eyes only once or did they evolve many times and lose their eyes independently? Different approaches have been used to determine the evolutionary relationships of cavefish, including allozyme analysis, biogeography, and phylogenetic reconstruction using molecular sequences. We will briefly consider the results obtained from the first two approaches and then describe the phylogenetic studies in more detail.

Figure 2 shows a map of the Sierra de El Abra region in northeastern Mexico illustrating the locations of known caves harboring Astyanax cavefish populations. The major cavefish region consists of the Sierra de El Abra, thé Sierra de Guatemala, the Micos region (Fig. 2), and the valleys lying between these limestone ridges in the states of Tamaulipas and San Luis Potosi, Mexico (Wilkens and Burns, 1972; Mitchell et al., 1977). An outlying cavefish population has also been discovered in the state of Guererro in south central Mexico (Espinasa et al., 2001).

In an electrophoretic study showing minimal divergence in 17 allozyme loci, Avise and Selander (1972) concluded that the Sierra de El Abra cavefish had a common origin. However, a limited number of cavefish populations (Pachon, Los Sabinos, and Chica; Fig. 2) were sampled in this study. In contrast, Mitchell et al. (1977), who surveyed 29 different cavefish populations in the Sierra de El Abra, Sierra de Guatemala, and Micos region, proposed several different origins of Astyanax cavefish. Mitchell et al. (1977) also estimated the divergence between surface fish and cavefish to have occurred about 10,000 to 100,000 years ago in the Sierra de El Abra region. The possibility of multiple cavefish origins is strongly supported by the recently discovered Guerrero cavefish from a cave located several hundred miles southwest of the main cavefish region (Espinasa et al, 2001).

The first phylogenetic studies of cavefish populations were done using DNA polymorphisms amplified by arbitrary primers (RAPDs) (Espinasa and Borowsky, 2001). This analysis supported a single origin of Sierra de El Abra cavefish and an independent origin of Subterraneo cavefish in the Micos region (Fig. 2). The limited number of RAPD markers scored in this study, however, left some uncertainty about the true relationships among the Sierra de El Abra cavefish. Thus far, it has proved difficult to obtain sufficiently variable sequence information from nuclear genes to construct robust phylogenetic trees, presumably due to the recent divergence of surface fish and cavefish. Thus, Dowling et al. (2002) were prompted to use NAD1 dehyrdogenase-2 (ND-2), a rapidly evolving mitochondrial gene, to infer cavefish relationships (Fig. 3).

Before discussing the resulting ND-2 mitochondrial DNA (mtDNA) phylogeny, it is necessary to comment on the currently unresolved taxonomy of A. mexicanus and related forms. Some taxonomists recognize two separate Astyanax species in Mexico: A. mexicanus in northern Mexico and Astyanax aeneus in southern Mexico (Obregon-Barbosa et al., 1994). Others be lieve that all Mexican and Central American Astyanax are a single species, Astyanax fasciatus (see Wilkens, 1988). Here, we defer to the first classification, designating the northern Mexican form as A. mexicanus, the southern Mexican form as A. aeneus, and the Central American form as A. fasciatus. Our justification is that these taxa are strongly supported by the mtDNA phylogeny (Fig. 3).

The mtDNA phylogeny infers at least two separate origins of cavefish, one before the divergence of the present day A. mexicanus and A. aeneus, and the other after the bifurcation of these taxa (Fig. 3). Accordingly, two distinct mtDNA lineages are recognized: the A lineage, including A. mexicanus and A. aeneus surface fish and Pachon and Subterraneo cavefish, and the B lineage, including Tinaja, Los Sabinos, and Curva cavefish (Dowling et al., 2002). The A lineage exhibits one of more than 20 different Type A ND-2 haplotypes, which vary from each other in only a few nucleotide positions and are mostly represented in surface fish. The B lineage exhibits one or two of only a few Type B ND-2 haplotypes, which differ in 7 or more nucleotide sites from the Type A haplotypes and are present in cavefish but not in any nearby surface fish populations. Sampling from Texas to Costa Rica failed to find any surface fish populations with Type B haplotypes (Dowling et al., 2002), suggesting that the surface fish stock that established the B lineage cavefish may be extinct.

Although the mtDNA tree has strong bootstrap support, our interpretation of these data must be treated with caution. First, the tree is based on only a single gene. However, a recent phylogenetic analysis has confirmed the topology of this tree using a different mitochondrial gene, cytochrome b (Strecker et al, 2003). second, mtDNA trees could be influenced by hybridization, which is known to have occurred between some of the cavefish populations and nearby surface fish (Mitchell et al, 1977; Romero, 1983; Langecker et al., 1991). Third, a recent phylogeny using microsatellite loci is more consistent with a common origin of the Sierra de El Abra cavefish (Strecker et al., 2003), suggesting replacement of mitochondrial DNA may have occurred by hybridization in Pachon cavefish. It is clear from the mtDNA data, however, that A and B lineage cavefish are genetically isolated populations.

In summary, separate origins with accompanying episodes of eye degeneration may have occurred in the Guerrero, Sierra de Guatemala (Molino), Micos (Subterraneo), and Lineage A and B Sierra de El Abra cavefish populations. Below we will compare the developmental mechanisms of eye degeneration in some of these cavefish.

THE LENS AS AN ORGANIZER OF EYE DEVELOPMENT

To determine the mechanisms of eye regression, we focused on the nature and timing of degenerative processes in the embryonic eye primordia. In every cavefish population we have studied, the eye primordium appears to be smaller than its surface fish counterpart. However, the cavefish eye seems to develop normally up to about the hatching stage, forming a lens and optic cup. Subsequently, development gradually arrests, the retina becomes disordered, and the degenerating eye disappears into the orbit (Cahn, 1958; Langecker et al., 1993). The cavefish lens does not differentiate arrays of aligned crystallin fibers and the retina, although at first layered normally, eventually shows disorganization and complete or partial loss of photoreceptor cells. In many developing systems, an alternative to cell differentiation is apoptosis: programmed cell death (White, 1996). Therefore, we first investigated whether apoptosis occurred during cavefish eye development.

If cell death is restricted to a single eye tissue, or begins in one tissue and later spreads to others, then the tissue that dies first is a strong candidate to initiate the degeneration process. Apoptosis was compared in surface fish and in Pachon cavefish embryos using the TUNEL assay (Jeffery and Martasian, 1998), which detects DNA fragmentation. Surface fish embryos showed little or no programmed cell death in the developing eye (Fig. 4A), except in the isthmus that temporarily forms between the budding lens and the surface ectoderm, as has been previously described in the mammalian eye (Silver and Hughes, 1968). Cavefish showed the same apoptotic event in a small number of isthmus cells as the lens vesicle pinched off from the surface ectoderm. About a day after the cavefish lens vesicle was formed, however, an additional and more extensive episode of apoptosis was detected in its central core (Fig. 4B), the region where lens fiber cells would normally differentiate from lens epithelial cells. No apoptosis was detected at this time in the surface fish lens (Fig. 4A), and no other cavefish eye tissue died at this stage of development. A few days later, the retina began to undergo apoptosis. Retinal cell death is restricted to the outer nuclear layer and the region adjacent to the ciliary marginal zone (CMZ) (A.G.S., unpublished), where most new retinal cells are produced in the teleost retina (Johns and Easter, 1977; Harris and Perron, 1998). Thus, the lens is the first tissue to undergo cell death during eye degeneration in Pachon cavefish.

Does the embryonic lens also die in other cavefish populations? Using the TUNEL assay, we showed that the Los Sabinos cavefish lens also dies before any other tissue in the degenerating eye (Fig. 4C). The results suggest that lens apoptosis may be responsible for triggering eye degeneration in both A and B lineage cavefish.

The cessation of retinal growth in cavefish could be caused by the failure of the dying lens to produce a growth-promoting factor or it could be due to an independent event in the retina. A reasonable candidate for an independent retinal event would be interference with cell proliferation. Surface fish have an active CMZ. Proliferating cells can be detected by incorporation of labeled nucleotides into DNA, the presence of the DNA polymerase cofactor PCNA, and the expression the homeobox genes RxI and Vsx2 (Fig. 4D, G), throughout the period of eye growth (Strickler et al, 2002; A.O.S., unpublished results). all of these cell proliferation markers were expressed in the Pachon cavefish CMZ (Fig. 4E, H), although the retina does not markedly increase in size during this period (Strickler et al., 2002). Presumably, new cells are removed from the retina soon after they are formed by the apoptotic events that begin a few days after the initiation of lens cell death.

We next asked whether the surprisingly wasteful process in which retinal cells appear to cycle quickly between birth and death also occurs in other cavefish populations? As shown in Figure F, I, RxI and Vsx2 are also expressed in the CMZ of Los Sabinos cavefish, despite a comparable lack of net growth. Thus, we conclude that arrest of cell proliferation is not the major cause of eye degeneration in A and B lineage cavefish populations.

The results described above focus our attention back to the lens. Does the lens organize the whole eye and could its removal by apoptosis result in the arrest of eye formation? The central role of the lens in eye formation has recently been appreciated (Beebe and Coats, 2000; Thut et al., 2001), due largely to developmental studies with cavefish (Yamamoto and Jeffery, 2000). We developed a lens transplantation assay to determine the role of the lens in surface fish eye development and in cavefish eye degeneration (Yamamoto and Jeffery, 2000, 2002).

The embryonic lens was removed from a donor embryo shortly after it pinched off from the surface ectoderm, about a day before the first detection of largescale apoptosis in the cavefish lens, and it was transplanted into the optic cup of a host embryo. Lens transplantation was done unilaterally, with the unoperated eye of the host serving as a control. The first transplantation experiments were carried out reciprocally between surface fish and Pachon cavefish: a surface fish lens was transplanted into a cavefish optic cup and vice versa (Yamamoto and Jeffery, 2000). These experiments also addressed the autonomy of programmed cell death in the cavefish lens: is cell death determined by the lens itself or is it induced by another tissue, for instance the retina? When a cavefish lens was transplanted into a surface fish optic cup it died on schedule, just as if it had not been removed from the donor embryo. Likewise, when a surface fish lens was transplanted into a cavefish optic cup it continued to grow and differentiated as it would have in the surface fish host. Together, these results indicate that the Pachon cavefish lens is autonomously fated for apoptosis, at least by the time of the transplantation (Yamamoto and Jeffery, 2000).

The autonomy of surface fish lens development in the cavefish host is the key part of the transplantation experiment. After obtaining a surface fish lens, the Pachon cavefish eye reversed its fate and began to grow and develop (Yamamoto and Jeffery, 2000). Eventually, the cornea and iris appeared, which are normally missing in cavefish, and the retina enlarged and became more organized. Further growth resulted in the presence of a highly developed eye containing all of the expected eye tissues, including the cornea, iris, and photoreceptor cells, in the adult Pachon cavefish host (Fig. 5B). When the donor lens was labeled with GFP no labeled cells appeared in the restored tissues of the host (Yamamoto and Jeffery, 2000). Thus, the rescued eye tissues arise from the host and not the donor. The cornea and iris are derived in part from optic neural crest cells, indicating that cavefish neural crest cells are present and located in the proper positions to be induced by the lens. In contrast to the eye with a transplanted lens, the unoperated eye of the cavefish host degenerated and disappeared into the orbit according to its usual schedule (Fig. 5A). Likewise, after obtaining a cavefish lens, development of the surface fish eye was retarded, the cornea and iris did not differentiate, and the size and organization of the retina was reduced. The degenerate surface fish eye eventually disappeared into the orbit (Fig. 5D), mimicking the cavefish eye. In contrast, the unoperated eye developed normally (Fig. 5C), resulting in a one-eyed surface fish.

Several conclusions can be made from the lens transplantation experiments. First, the lens is an organizer of optic development, mediating differentiation of the cornea and iris and survival and growth of the retina and cornea. Whether the lens sends an instructive or a permissive signal to these tissues is currently under investigation. second, the cavefish lens has lost the ability to organize the eye, presumably as a result of apoptosis. Third, despite the loss of its own lens, the cavefish eye and accessory tissues have retained the ability to respond to signals generated by a normal surface fish lens. Thus, the lens plays a key role in eye degeneration in Pachon cavefish.

We next asked whether the lens is central to eye degeneration in other cavefish populations. The lens transplantation experiments were repeated in Los Sabinos cavefish (Fig. 5E-H). The results were the same: a surface fish lens was able to restore eye formation in a Los Sabinos cavefish host, and the lens from a Los Sabinos cavefish transplanted into a surface fish optic cup was unable to mediate eye development in the surface fish host. Thus, the eye degeneration process appears to be very similar, if not identical, in Los Sabinos and Pachon cavefish. In both cases, evolutionary changes have targeted the lens.

GENES INVOLVED IN EYE DEGENERATION

Many different eye development genes have been identified in vertebrates. This resource prompted us to take a candidate gene approach to characterize the genes involved in cavefish eye degeneration. The approach involves obtaining the sequences of known eye genes by Reverse Transcription PCR with degenerate primers and comparing their expression patterns in surface fish and cavefish embryos by in situ hybridization.

Our candidate gene survey includes genes encoding transcription factors that function near the top of eye gene hierarchies, as well as structural genes encoding proteins that function at the bottom of the gene cascades. Most of the surveyed genes did not show any changes in expression in surface fish and cavefish embryos. For example, the transcription factor Proxl is expressed normally in the developing lens and retina of Pachon and Los Sabinos cavefish until after the eye begins to degenerate (Jeffery et al, 2000), indicating that it could not have a causal role in regression. Likewise, prior to lens degeneration, the [beta] and gammaM crystallin genes are expressed in the cavefish lens (Jeffery et ai, 2000), despite lack of lens fiber cell differentiation and diversion into a cell death pathway. The gamma crystallin protein is also synthesized in the cavefish lens (A.G.S., unpublished). Langecker et al. (1993) noted a similar pattern of opsin gene expression in the outer nuclear layer of the cavefish retina. The changes that did occur in cavefish gene expression in our survey were subtle and appeared very early in eye development (A.G.S. and Y.Y., unpublished). Below we describe the early changes in Paxo gene expression and their implications for the regulation of cavefish eye development.

Paxo encodes a transcription factor (Gehring and Ikeo, 1999) that is expressed in the lens placodes and optic primordia (presumptive retina and retinal pigment epithelium) early in teleost eye development (Krauss et al., 1991; Puschel et al., 1998). This well studied gene is known to play a fundamental role in many aspects of eye development in both invertebrates and vertebrates (Halder et ai, 1995; Ashley-Padan et al., 2000). Interestingly, the morphology of the small eye primordium in cavefish embryos resembles the Small eye phenotype in mouse, which is caused by a mutation in the Paxo gene (Hill et al, 1991). Our PCR analysis and library screen detected a single Paxo gene in Astyanax (Strickler et al., 2001), although two genes have been described in zebrafish (Nornes et al., 1998). Astyanax Paxo is expressed in the lens placode, presumptive retina, and in parts of the central nervous system during early development. Later, Paxo expression becomes restricted to the lens epithelial cells, the ganglion and amacrine cells of the retina, and the corneal epithelium. Below we consider Paxo expression patterns in the neural plate of cavefish embryos.

The teleost eye arises from two regions at the neurula stage: the bilaterally symmetric optic fields, which are located in the anterior neural plate, and the lens placodes, which are located in the surface ectoderm just outside the anterior margin of the neural plate. After the neural tube appears, each optic field forms an optic vesicle. The optic vesicle then rotates through an angle of about 90° to form a lateral optic cup and a medial optic stalk (see Fig. 7A-B). Next, the lens placode buds into the space within the optic cup to form the embryonic lens. Finally, the retina and retinal pigment epithelium differentiate from the optic cup, and the optic nerve develops from the optic stalk.

In surface fish embryos, bilateral Paxo expression domains, which coincide with the optic fields in the anterior neural plate, connect across the midline at their anterior margins (Fig. 6A, B). In Pachon cavefish embryos, however, the Paxo domains are slightly diminished in size and show a gap across the midline (Fig. 6C, D). Paxo expression in the lens placodes was also diminished in Pachon cavefish embryos (Fig. 6C, D). Controls showing that Dlx-3 and Pax2 expression were unchanged at the same developmental stage (Strickler et al, 2001, Y.Y., unpublished) indicated that Pax6 expression is downregulated in cavefish. The decrease in Pax6 expression may explain the decreased size of the cavefish lens and optic cup.

We next examined Pax6 expression in Los Sabinos and Curva cavefish embryos (Fig. 6E-H). Similar results were obtained: Pax6 expression was reduced in the optic fields, a midline gap was present between the bilateral expression domains, and expression was reduced or absent in the lens placodes. The results indicate that similar changes in Pax.6 expression occur in the eye primordia of A and B lineage cavefish embryos.

The division of the optic vesicle into the optic cup and stalk is controlled by reciprocal repression between the Pax6 and Pax2 transcription factors (Schwarz et al, 2000). Pax6 directs optic cup development, whereas Pax2 controls optic stalk development. Accordingly, a reduction of Pax6 levels (or an increase in Pax2 levels) is expected to increase the optic stalk at the expense of the optic cup, leading to reduction in the size of the ventral optic cup. The antagonism between Pax6 and Pax2 function during optic primordium development is illustrated in Figure 7A, B. Consistent with a diminished Pax6 expression domain, the optic cup is ventrally reduced and its ventral sector is replaced by optic stalk in Pachon, Tinaja, and Curva cavefish embryos (Fig. 7C-F). Thus, reduction of the Pax6 expression domains has the same phenotypic effects on eye formation in A and B lineage cavefish.

DISCUSSION

We compared eye degeneration in A lineage Pachon cavefish and several B lineage cavefish populations. Based on the mtDNA tree, A and B lineage cavefish were inferred to evolve at different times from distinct surface fish ancestors, implying that they lost their eyesight independently. Multiple origins of blind cavefish in the genus Astyanax would be consistent with convergent reduction and loss of eyes that has been described in many different species of cave adapted fishes (Romero and Paulson, 2001). Although there is still uncertainty about the reliability of mtDNA for inferring the phylogenetic relationships between closely related taxa (Shaw, 2002), the mtDNA phylogeny is supported by genetic complementation in the progeny of a cross between Pachon and Los Sabinos cavefish (Wilkens, 1971). Therefore, at least some of the genes responsible for eye degeneration must be different in A and B lineage cavefish populations. Current studies are consistent with at least four (Guerrero, Sierra de Guatemala, Subterraneo, Sierra de El Abra cavefish populations) and possibly five (A and B lineage Sierra de El Abra cavefish populations) showing independent origins and visual degeneration episodes in Astyanax cavefish.

Eye development pathways are modified in the same or very similar ways in A and B lineage cavefish. Embryos of both types of cavefish initially form optic primordia consisting of a small lens and a ventrally reduced optic cup. Retinal cell differentiation begins on schedule but eye growth and development are gradually arrested, and the degenerating eye sinks into the orbit. Surprisingly, cessation of cell proliferation is not the primary cause of arrested retinal development in Faction or Los Sabinos cavefish (Strickler et al., 2002). The Vsx2 and RxI genes, positive indicators of retinal cell division, are expressed strongly in the CMZ, implying that degenerative events may cancel the addition of new cells.

In A and B lineage cavefish, lens cell death is a prelude to general optic arrest and degeneration, suggesting that the lens plays a central role in the loss of vision. Indeed, a surface fish embryonic lens can rescue eye development, including the induction of the cornea and iris and the restoration of retinal growth, after transplantation into the optic cup of a Pachon or a Los Sabinos cavefish embryo. Thus, lens apoptosis mediates eye degeneration in A and B lineage cavefish populations.

The following scenario is proposed for loss of vision in cavefish. The developing lens normally produces a factor(s) that is responsible for inducing differentiation of the anterior eye segment (e.g., cornea and iris) and sustaining retinal growth by suppression of apoptosis. The signal(s) is either greatly reduced or absent in the cavefish lens after it switches to an apoptotic pathway. Although generation of new cells in the retina (and other eye parts?) is not prevented, cell death triggered by the absence of the lens signal prohibits net growth, degeneration begins, and the cavefish eye is overwhelmed by rapid growth of the body. Therefore, cavefish eye degeneration does not appear to be an economic process: considerable metabolic energy must be expended by the continuous generation of new retinal cells that are eventually bound to die. These results appear to be inconsistent with any theory of cavefish eye regression that assigns a positive selective value to energy conservation.

Because apoptosis can result from changes in different genes, it was important to compare the expression patterns of many genes in different cavefish populations. Genetic crosses show that 3 to 6 genes are responsible for eye regression in Pachon cavefish (Wilkens, 1988). Although still in its early stages, our eye candidate gene survey has not revealed any genes with complete loss of function or gross changes in expression patterns in cavefish embryos (Jeffery etal., 2000; Strickler et al, 2001, 2002; A.G.S. and Y.Y., unpublished results). Instead, the changes we have seen are modest, spatial rather than temporal, and occur early in development, allowing them to be magnified into larger changes as development continues.

The subtle modifications in Pax6 expression suggest a role in generating the cavefish eyeless phenotype. The important differences in early cavefish embryos are reduced Pax6 expression in the bilateral optic fields and a wider gap between the expression domains at the anterior midline. The prechordal mesoderm lies immediately beneath the anterior neural plate during optic field determination. Hedgehog (Hh) proteins diffusing from the prechordal mesoderm regulate the size of the optic primordia by suppresing Pax6 expression in the overlying neural plate (Ekker et ai, 1995; Macdonald et al, 1995; Li et ai, 1997). Likewise, reduced Pax6 expression in the optic fields is expected to change the fate of the ventral optic cup via relaxing the normal transcriptional repression of Pax2, which directs optic stalk development (Schwarz et al., 2000). A ventrally reduced optic cup was observed in A and B lineage cavefish embryos.

Diminutive Pax6 domains and optic cups without ventral sectors in cavefish embryos may be a consequence of hyperactive Hh midline signaling. Experiments in progress (Y.Y., unpublished results) show that expression of the midline signaling gene Sonic hedge-hog (Shh) is increased and expanded in the prechordal mesoderm of both Pachon and Los Sabinos cavefish embryos. Furthermore, Pax2 expression is also expanded in cavefish optic vesicles and upregulation of midline signaling by injecting Shh mRNA into surface fish embryos results in a phenocopy of the cavefish eye, including a change of fate in the optic cup, lens apoptosis, arrest of eye development, and loss of vision.

The developmental and gene expression studies have revealed a negative relationship between midline signaling and eye formation, which could have major implications for cavefish eye regression. Thus, eyes could be lost as a secondary consequence of expanded midline signaling, which could promote enhancement of other sensory organs that may be advantageous to the survival of blind cavefish. We have recently shown that Shh is both sufficient and necessary for the differentiation of taste bud primordia (Y. Y., unpublished), which could be one of the affected sensory organs.

We opened this paper with Darwin's quote discounting a role of natural selection in blinding cave animals. The difficulty in explaining eye regression by natural selection resulted in the popularity of the neutral mutation hypothesis. The results of the developmental studies described here are largely inconsistent with neutral mutation as the only force responsible for eye degeneration. First, loss of the eye by the same mechanisms in different cavefish populations would not be expected according to the neutral mutation hypothesis. second, continued expression of genes with functions restricted to the eye, such as the [beta] and gamma crystallins (Jeffery et al., 2000) and other genes encoding lens proteins (A.G.S., unpublished), would not be predicted. According to the neutral mutation hypothesis, loss of function mutations would be expected to accumulate in these genes over time. Behrens et al. (1998) also concluded that the cavefish alphaA crystallin gene is structurally intact, although they were unable to detect transcripts in the lens. Third, parallel changes in gene expression in different cavefish populations would not be expected according to the neutral mutation hypothesis. The developmental results are more adequately explained by natural selection acting through pleiotropic genes that simultaneously promote some of the constructive features and suppress some of the regressive features of the cavefish phenotype. Recent QTL analysis has also suggested a possible role for pleiotropy in the co-evolution of constructive and regressive traits in Astyanax cavefish (Borowsky and Wilkens, 2002). QTL analysis may eventually lead to the discovery of more candidates for genes controlling eye degeneration in cavefish.

Previous attempts to explain cavefish eye degeneration invoke either the neutral mutation or adaptation hypotheses, which are not mutually exclusive. In addition to the developmental studies reviewed here, any attempt to understand the evolution of eye degeneration also must take into account the results of genetic crosses showing that some of the genes involved in eye degeneration are different in A and B lineage cavefish (Wilkens, 1971). Some of the progeny of Pachon X Los Sabinos cavefish crosses were found to have less degenerate eyes than either parent, suggesting different eye genes have been modified in these cavefish populations. Similar results have been obtained by crossing Pachon and Subterraneo cavefish (Y.Y., unpublished). Accordingly, we propose that both natural selection and neutral mutation may have contributed to the loss of eyes in Astyanax cavefish.

Eye degeneration could have occurred in two steps, the first mediated by natural selection and the second by neutral mutation. Natural selection could have initiated the eye degeneration as a tradeoff between forming complete eyes and enhancing taste buds and other cranial sensory organs. The tradeoff may be controlled by Shh and other pleiotropic genes, whose midline signaling domains are expanded in cavefish embryos. Subsequently, neutral mutations may have accumulated in different eye genes as eye regression continued under relaxed selection in the cave environment.

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The claim that creationism is a science rests above all on the plausibility of the biblical flood

by Stephen Jay Gould

G.K.CHESTERTON once mused over Noah's dinnertime conversations during those long nights on a vast and tempestuous sea:

And Noah he often said to his wife
when he sat down to dine,
"I don't care where the water goes if
it doesn't get into the wine."

Noah's insouciance has not been matched by defenders of his famous flood. For centuries, fundamentalists have tried very hard to find a place for the subsiding torrents. They have struggled even more valiantly to devise a source for all that water. Our modern oceans, extensive as they are, will not override Mt. Everest. One seventeenth-century searcher said: "I can as soon believe that a man would be drowned in his own spittle as that the world should be deluged by the water in it."

With the advent of creationism, a solution to this old dilemma has been put forward. In The Genesis Flood (1961), the founding document of the creationist movement, John Whitcomb and Henry Morris seek guidance from Genesis 1:6-7, which states that God created the firmament and then slid it into place amidst the waters, thus dividing "the waters which were under the firmament from the waters which were above the firmament: and it was so." The waters under the firmament include seas and interior fluid that may rise in volcanic eruptions. But what are the waters above the firmament? Whitcomb and Morris reason that Moses cannot refer here to transient rain clouds, because he also tells us (Genesis 2:5) that "the Lord God had not caused it to rain upon the earth." The authors therefore imagine that the earth, in those palmy days, was surrounded by a gigantic canopy of water vapor (which, being invisible, did not obscure the light of Genesis 1:3). "These upper waters," Whitcomb and Morris write, "were therefore placed in that position by divine creativity, not by the normal processes of the hydrological cycle of the present day." Upwelling from the depths together with the liquefaction, puncturing, and descent of the celestial canopy produced more than enough water for Noah's worldwide flood.

Fanciful solutions often generate a cascade of additional difficulties. In this case, Morris, a hydraulic engineer by training, and Whitcomb invoke a divine assist to gather the waters into their canopy, but then can't find a natural way to get them down. So they invoke a miracle: God put the water there in the first place; let him then release it.

The simple fact of the matter is that one cannot have any kind of a Genesis Flood without acknowledging the presence of supernatural elements.... It is obvious that the opening of the "windows of heaven" in order to allow "the waters which were above the firmament" to fall upon the earth, and the breaking up of "all the fountains of the great deep" were supernatural acts of God.

Since we usually define science, at least in part, as a system of explanation that relies upon invariant natural laws, this charmingly direct invocation of miracles (suspensions of natural law) would seem to negate the central claims of the modern creationist movement -- that creationism is not religion but a scientific alternative to evolution; that creationism has been disregarded by scientists because they are a fanatical and dogmatic lot who cannot appreciate new advances; and that creationists must therefore seek legislative redress in their attempts to force a "balanced treatment" for both creationism and evolution in the science classrooms of our public schools.

Legislative history has driven creationists to this strategy of claiming scientific status for their religious view. The older laws, which banned the teaching of evolution outright and led to John Scopes's conviction in 1925, were overturned by the Supreme Court in 1968, but not before they had exerted a chilling effect upon teaching for forty years. (Evolution is the indispensable organizing principle of the life sciences, but I did not hear the word in my 1956 high school biology class. New York City, to be sure, suffered no restrictive ordinances, but publishers, following the principle of the "least common denominator" as a sales strategy, tailored the national editions of their textbooks to the few states that considered it criminal to place an ape on the family escutcheon.) A second attempt to mandate equal time for frankly religious views of life's history passed the Tennessee state legislature in the 1970s but failed a constitutional challenge in the court. This judicial blocking left only one legislative path open -- the claim that creationism is a science.

The third strategy had some initial success, and "balanced treatment" acts to equate "evolution science" and "creation science" in classrooms passed the Arkansas and Louisiana legislatures in 1981. The ACLU has sued for a federal-court ruling on the Louisiana law's constitutionality, and a trial is likely this year. The Arkansas law was challenged by the ACLU in 1981, on behalf of local plaintiffs (including twelve practicing theologians who felt more threatened by the bill than many scientists did). Federal Judge William R. Overton heard the Arkansas case in Little Rock last December. I spent the better part of a day on the stand, a witness for the prosecution, testifying primarily about how the fossil record refutes "flood geology" and supports evolution.

On January 5, Judge Overton delivered his eloquent opinion, declaring the Arkansas act unconstitutional because so-called "creation science" is only a version of Genesis read literally -- a partisan (and narrowly sectarian) religious view, barred from public-school classrooms by the First Amendment. Legal language is often incomprehensible, but sometimes it is charming, and I enjoyed the wording of Overton's decision: "...judgment is hereby entered in favor of the plaintiffs and against the defendants. The relief prayed for is granted."

Support for Overton's equation of "creation science" with strident and sectarian fundamentalism comes from two sources. First, the leading creationists themselves released some frank private documents in response to plaintiffs' subpoenas. Overton's long list of citations seems to brand the claim for scientific creationism as simple hypocrisy. For example, Paul Ellwanger, the tireless advocate and drafter of the "model bill" that became Arkansas Act 590 of 1981, the law challenged by the ACLU, says in a letter to a state legislator that "I view this whole battle as one between God and anti-God forces, though I know there are a large number of evolutionists who believe in God.... it behooves Satan to do all he can to thwart our efforts..." In another letter, he refers to "the idea of killing evolution instead of playing these debating games that we've been playing for nigh over a decade already" -- a reasonably clear statement of the creationists' ultimate aims, and an identification of their appeals for "equal time," "the American way of fairness," and "presenting them both and letting the kids decide" as just so much rhetoric.

The second source of evidence of the bill's unconstitutionality lies in the logic and character of creationist arguments themselves. The flood story is central to all creationist systems. It also has elicited the only specific and testable theory the creationists have offered; for the rest, they have only railed against evolutionary claims. The flood story was explicitly cited as one of the six defining characteristics of "creation science" in Arkansas Act 590: "explanation of the earth's geology by catastrophism, including the occurrence of a worldwide flood."

CREATIONISM reveals its nonscientific character in two ways: its central tenets cannot be tested and its peripheral claims, which can be tested, have been proven false. At its core, the creationist account rests on "singularities" -- that is to say, on miracles. The creationist God is not the noble clock winder of Newton and Boyle, who set the laws of nature properly at the beginning of time and then released direct control in full confidence that his initial decisions would require no revision. He is, instead, a constant presence, who suspends his own laws when necessary to make the new or destroy the old. Since science can treat only natural phenomena occurring in a context of invariant natural law, the constant invocation of miracles places creationism in another realm.

We have already seen how Whitcomb and Morris remove a divine finger from the dike of heaven to flood the earth from their vapor canopy. But the miracles surrounding Noah's flood do not stop there; two other supernatural assists are required. First, God acted "to gather the animals into the Ark." (The Bible tells us [Genesis 6:20] that they found their own way.) Second, God intervened to keep the animals "under control during the year of the Flood." Whitcomb and Morris provide a long disquisition on hibernation and suspect that some divinely ordained state of suspended animation relieved Noah's small and aged crew of most responsibility for feeding and cleaning (poor Noah himself was 600 years old at the time).

In candid moments, leading creationists will admit that the miraculous character of origin and destruction precludes a scientific understanding. Morris writes (and Judge Overton quotes): "God was there when it happened. We were not there.... Therefore, we are completely limited to what God has seen fit to tell us, and this information is in His written Word." Duane Gish, the leading creationist author, says: "We do not know how the Creator created, what processes He used, for He used processes which are not now operating anywhere in the natural universe.... We cannot discover by scientific investigation anything about the creative processes used by God." When pressed about these quotes, creationists tend to admit that they are purveying religion after all, but then claim that evolution is equally religious. Gish also says: "Creationists have repeatedly stated that neither creation nor evolution is a scientific theory (and each is equally religious)." But as Judge Overton reasoned, if creationists are merely complaining that evolution is religion, then they should be trying to eliminate it from the schools, not struggling to get their own brand of religion into science classrooms as well. And if, instead, they are asserting the validity of their own version of natural history, they must be able to prove, according to the demands of science, that creationism is scientific.

Scientific claims must be testable; we must, in principle, be able to envision a set of observations that would render them false. Miracles cannot be judged by this criterion, as Whitcomb and Morris have admitted. But is all creationist writing merely about untestable singularities? Are arguments never made in proper scientific form? Creationists do offer some testable statements, and these are amenable to scientific analysis. Why, then, do I continue to claim that creationism isn't science? Simply because these relatively few statements have been tested and conclusively refuted. Dogmatic assent to disproved claims is not scientific behavior. Scientists are as stubborn as the rest of us, but they must be able to change their minds.

In "flood geology," we find our richest source of testable creationist claims. Creationists have been forced into this uncharacteristically vulnerable stance by a troubling fact too well known to be denied: namely, that the geological record of fossils follows a single, invariant order throughout the world. The oldest rocks contain only single-celled creatures; invertebrates dominate later strata, followed by the first fishes, then dinosaurs, and finally large mammals. One might be tempted to take a "liberal," or allegorical, view of Scripture and identify this sequence with the order of creation in Genesis 1, allowing millions or billions of years for the "days" of Moses. But creationists will admit no such reconciliation. Their fundamentalism is absolute and uncompromising. If Moses said "days," he meant periods of twenty-four hours, to the second. (Creationist literature is often less charitable to liberal theology than to evolution. As a subject for wrath, nothing matches the enemy within.)

Since God created with such alacrity, all creatures once must have lived simultaneously on the earth. How, then, did their fossil remains get sorted into an invariable order in the earth's strata? To resolve this particularly knotty dilemma, creationists invoke Noah's flood: all creatures were churned together in the great flood and their fossilized succession reflects the order of their settling as the waters receded. But what natural processes would produce such a predictable order from a singular chaos? The testable proposals of "flood geology" have been advanced to explain the causes of this sorting.

Whitcomb and Morris offer three suggestions. The first -- hydrological -- holds that denser and more streamlined objects would have descended more rapidly and should populate the bottom strata (in conventional geology, the oldest strata). The second -- ecological -- envisions a sorting responsive to environment. Denizens of the ocean bottom were overcome by the flood waters first, and should lie in the lower strata; inhabitants of mountaintops postponed their inevitable demise, and now adorn our upper strata. The third -- anatomical or functional -- argues that certain animals, by their high intelligence or superior mobility, might have struggled successfully for a time, and ended up at the top.

All three proposals have been proven false. The lower strata abound in delicate, floating creatures, as well as spherical globs. Many oceanic creatures -- whales and teleost fishes in particular -- appear only in upper strata, well above hordes of terrestrial forms. Clumsy sloths (not to mention hundreds of species of marine invertebrates) are restricted to strata lying well above others that serve as exclusive homes for scores of lithe and nimble small dinosaurs and pterosaurs.

The very invariance of the universal fossil sequence is the strongest argument against its production in a single gulp. Could exceptionless order possibly arise from a contemporaneous mixture by such dubious processes of sorting? Surely, somewhere, at least one courageous trilobite would have paddled on valiantly (as its colleagues succumbed) and won a place in the upper strata. Surely, on some primordial beach, a man would have suffered a heart attack and been washed into the lower strata before intelligence had a chance to plot temporary escape. But if the strata represent vast stretches of sequential time, then invariant order is an expectation, not a problem. No trilobite lies in the upper strata because they all perished 225 million years ago. No man keeps lithified company with a dinosaur, because we were still 60 million years in the future when the last dinosaur perished.

TRUE science and religion are not in conflict. The history of approaches to Noah's flood by scientists who were also professional theologians provides an excellent example of this important truth -- and also illustrates just how long ago "flood geology" was conclusively laid to rest by religious scientists. I have argued that direct invocation of miracles and unwillingness to abandon a false doctrine deprive modern creationists of their self-proclaimed status as scientists. When we examine how the great scientist-theologians of past centuries treated the flood, we note that their work is distinguished by both a conscious refusal to admit miraculous events into their explanatory schemes and a willingness to abandon preferred hypotheses in the face of geological evidence. They were scientists and religious leaders -- and they show us why modern creationists are not scientists.

On the subject of miracles, the Reverend Thomas Burnet published his century's most famous geological treatise in the 1680s, Telluris theoria sacra (The Sacred Theory of the Earth). Burnet accepted the Bible's truth, and set out to construct a geological history that would be in accord with the events of Genesis.

But he believed something else even more strongly: that, as a scientist, he must follow natural law and scrupulously avoid miracles. His story is fanciful by modern standards: the earth originally was devoid of topography, but was drying and cracking; the cracks served as escape vents for internal fluids, but rain sealed the cracks, and the earth, transformed into a gigantic pressure cooker, ruptured its surface skin; surging internal waters inundated the earth, producing Noah's flood. Bizarre, to be sure, but bizarre precisely because Burnet would not abandon natural law. It is not easy to force a preconceived story into the strictures of physical causality. Over and over again, Burnet acknowledges that his task would be much simpler if only he could invoke a miracle. Why weave such a complex tale to find water for the flood in a physically acceptable manner, when God might simply have made new water for his cataclysmic purification? Many of Burnet's colleagues urged such a course, but he rejected it as inconsistent with the methods of "natural philosophy" (the word "science" had not yet entered English usage):

They say in short that God Almighty created waters on purpose to make the Deluge ... And this, in a few words, is the whole account of the business. This is to cut the knot when we cannot loose it.

Burnet's God, like the deity of Newton and Boyle, was a clock-winder, not a bungler who continually perturbed his own system with later corrections.

We think him a better Artist that makes a Clock that strikes regularly at every hour from the Springs and Wheels which he puts in the work, than he that hath so made his Clock that he must put his finger to it every hour to make it strike: And if one should contrive a piece of Clockwork so that it should beat all the hours, and make all its motions regularly for such a time, and that time being come, upon a signal given, or a Spring toucht, it should of its own accord fall all to pieces; would not this be look'd upon as a piece of greater Art, than if the Workman came at that time prefixt, and with a great Hammer beat it into pieces?

Flood geology was considered and tested by early-nineteenth-century geologists. They never believed that a single flood had produced all fossil-bearing strata, but they did accept and then disprove a claim that the uppermost strata contained evidence for a single, catastrophic, worldwide inundation. The science of geology arose in nations that were glaciated during the great ice ages, and glacial deposits are similar to the products of floods. During the 1820s, British geologists carried out an extensive empirical program to test whether these deposits represented the action of a single flood. The work was led by two ministers, the Reverend Adam Sedgwick (who taught Darwin his geology) and the Reverend William Buckland. Buckland initially decided that all the "superficial gravels" (as these deposits were called) represented a single event, and he published his Reliquiae diluvianae (Relics of the Flood) in 1824. However, Buckland's subsequent field work proved that the superficial gravels were not contemporaneous but represented several different events (multiple ice ages, as we now know). Geology proclaimed no worldwide flood but rather a long sequence of local events. In one of the great statements in the history of science, Sedgwick, who was Buckland's close colleague in both science and theology, publicly abandoned flood geology and upheld empirical science -- in his presidential address to the Geological Society of London in 1831.

Having been myself a believer, and, to the best of my power, a propagator of what I now regard as a philosophic heresy, and having more than once been quoted for opinions I do not now maintain, I think it right, as one of my last acts before I quit this Chair, thus publicly to read my recantation...

There is, I think, one great negative conclusion now incontestably established -- that the vast masses of diluvial gravel, scattered almost over the surface of the earth, do not belong to one violent and transitory period...

We ought, indeed, to have paused before we first adopted the diluvian theory, and referred all our old superficial gravel to the action of the Mosaic flood... In classing together distant unknown formations under one name; in giving them a simultaneous origin, and in determining their date, not by the organic remains we had discovered, but by those we expected hypothetically hereafter to discover, in them; we have given one more example of the passion with which the mind fastens upon general conclusions, and of the readiness with which it leaves the consideration of unconnected truths.

As I prepared to leave Little Rock last December, I went to my hotel room to gather my belongings and found a man sitting backward on my commode, pulling it apart with a plumber's wrench. He explained to me that a leak in the room below had caused part of the ceiling to collapse and he was seeking the source of the water. My commode, located just above, was the obvious candidate, but his hypothesis had failed, for my equipment was working perfectly. The plumber then proceeded to give me a fascinating disquisition on how a professional traces the pathways of water through hotel pipes and walls. The account was perfectly logical and mechanistic: it can come only from here, here, or there, flow this way or that way, and end up there, there, or here. I then asked him what he thought of the trial across the street, and he confessed his staunch creationism, including his firm belief in the miracle of Noah's flood.

As a professional, this man never doubted that water has a physical source and a mechanically constrained path of motion -- and that he could use the principles of his trade to identify causes. It would be a poor (and unemployed) plumber indeed who suspected that the laws of engineering had been suspended whenever a puddle and cracked plaster bewildered him. Why should we approach the physical history of our earth any differently?

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Views That Facts Can't Shake

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By Ellen Goodman
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BOSTON -- The medical examiners delivered their autopsy report in the most matter-of-fact tone. Terri Schiavo's brain had atrophied to half the normal size for a woman her age. Her eyes, the focus of that famous videotape, saw nothing. She was blind.

The examiners couldn't say why Terri collapsed 15 years ago. But they could say she wasn't abused by her husband. They could say that "no amount of treatment or rehabilitation would have reversed" her condition. There was no doubt about it.

Case closed? As the news conference replayed, the television screen spelled out a question for cable viewers: "Does This Change Opinions?" Did the facts of a case that had so divided the country, so politicized the fate of one woman, actually make a difference?

For Schiavo's parents, the answer was no. The Schindlers still insist their daughter related to them and tried to speak. Their lawyer said it only proved that "she was not terminal." The president said only that he "was deeply saddened by this case." His brother, the governor of Florida, said he would still have tried to keep Schiavo alive.

And if the autopsy changed the opinions of politicians such as Doctor/Senator Bill Frist, who disgraced his first profession by diagnosing a videotape, they were not in the mood for apologies.

This case was never solely about medicine. But the question on the TV screen illustrated the times we live in -- times when facts can exist in a separate universe from opinions. And a country in which science is seen not as a matter of black and white but increasingly as a matter of red and blue.

The Schiavo case is not the only example. The climate is equally apparent in the struggle over what the Bush administration calls "climate change" -- and everyone else calls global warming. The only way to justify doing nothing about global warming now is to deliberately muddle the science. It's not an accident that Philip Cooney, the White House official caught editing reports on greenhouse gases, left for Exxon Mobil, which has indeed funded doubts.

So, too, the struggle over evolution is no longer overtly between scientists and religious fundamentalists. It's between the science establishment and the handful of front men with PhDs who support "intelligent design." Their credentials make it seem as if evolution were also a matter of genuine scientific debate.

Meanwhile, reports of a link between breast cancer and abortion reappear on Web sites with the tenacity of urban legends. Stories continually report, most recently in Ohio, fantasies presented as facts in abstinence-only education programs being funded by the government. They link birth control pills with infertility, and HIV with French-kissing. But when they are debunked, "Does This Change Opinions?"

James Wagoner of Advocates for Youth describes the trend this way: "If science doesn't fit the ideology, you shop and find your own science." Just last week the Heritage Foundation, an overtly conservative think tank, was given a government platform to attempt to debunk, indeed to attack, an earlier study on virginity pledges.

The original, peer-reviewed study by researchers at Columbia and Yale universities found that young people who make virginity pledges may delay intercourse, but ultimately end up with rates of sexually transmitted diseases similar to their peers. The Heritage team makes a counterclaim, in a paper that was presented at a forum sponsored by the Department of Health and Human Services, that pledgers have lower STDs and fewer risky behaviors.

With its flawed methodology, the Heritage study may never be published, but as Wagoner said, "They don't have to win the scientific debate, they only have to muddy the water." In a day when unvetted research becomes public as quickly as rumors on the Internet, it enters the data bank as "scientific proof" that virginity pledges "work."

As Peter Bearman, co-author of the original study, says ruefully, "Science has often been deployed for political reasons. The deployment of science is different than the distortion of science. That's what is happening now."

It doesn't help that 15.5 percent of the scientists in a recent survey said they changed something in a study to satisfy a sponsor. It's bad enough when the sponsor is a drug company, worse when it's an ideological purveyor.

Maybe it's a good sign that even ideologues still need scientists to make their case legitimate. But what happens when science is seen and even skewed as partisan? Is one scientist's fact given no more weight than another's opinion?

At the height of the Schiavo furor, I saw a protester carrying a sign that asked: "How do you kill someone while she's smiling at you?" Now we know beyond any doubt that Terri Schiavo couldn't smile. Does this fact change even one opinion?

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GOD'S UTILITY FUNCTION

- Richard Dawkins

Chapter from River Out of Eden

My clerical correspondent of the previous chapter found faith through a wasp. Charles Darwin lost his with the help of another: "I cannot persuade myself," Darwin wrote, "that a beneficent and omnipotent God would have designedly created the Ichneumonidae with the express intention of their feeding within the living bodies of Caterpillars." Actually Darwin's gradual loss of faith, which he downplayed for fear of upsetting his devout wife Emma, had more complex causes. His reference to the Ichneumonidae was aphoristic. The macabre habits to which he referred are shared by their cousins the digger wasps, whom we met in the previous chapter. A female digger wasp not only lays her egg in a caterpillar (or grasshopper or bee) so that her larva can feed on it but, according Fabre and others, she carefully guides her sting into each ganglion of the prey's central nervous system, so as to paralyze it but not kill it. This way, the meat keeps fresh. It is not known whether the paralysis acts as a general anesthetic, or if it is like curare in just freezing the victim's ability to move. If the latter, the prey might be aware of being eaten alive from inside but unable to move a muscle to do anything about it. This sounds savagely cruel but, as we shall see, nature is not cruel, only pitilessly indifferent. This is one of the hardest lessons for humans to learn. We cannot admit that things might be neither good nor evil, neither cruel nor kind, but simply callous-indifferent to all suffering, lacking all purpose.

We humans have purpose on the brain. We find it hard to look at anything without wondering what it is "for", what the motive for it is, or the purpose behind it. When the obsession with purpose becomes pathological it is called paranoia-reading malevolent purpose into what is actually random bad luck. But this is just and exaggerated form of a nearly universal delusion. Show us almost any object or process, and it is hard for us to resist the "Why" question-the "What is it for?" question.

The desire to see purpose everywhere is a natural one in an animal that lives surrounded by machines, works of art, tools and other designed artifacts; an animal, moreover, whose waking thoughts are dominated by its own personal goals. A car, a tin opener, a screwdriver and pitchfork all legitimately warrant the "What is it for?" question. Our pagan forebears would have asked the same question about thunder, eclipses, rocks and streams. Today we pride ourselves on having shaken off such primitive animism. If a rock in a stream happens to serve as a convenient steppingstone, we regard its usefulness as an accidental bonus, not a true purpose. But the old temptation comes back with a vengeance when tragedy strikes-indeed, the very word "strikes" is an animistic echo: "Why, oh why, did the cancer/earthquake/hurricane have to strike my child?" And the same temptation is often positively relished when the topic is the origin of all things or the fundamental laws of physics, culminating in the vacuous existential question "Why is there something rather than nothing?"

I have lost count of the number of times a member of the audience has stood up after a public lecture I have given and said something like the following: "You scientists are very good at answering 'How' questions. But you must admit you're powerless when it comes to 'Why' questions." Prince Philip, Duke of Edinburgh, made this very point when he was in an audience at Windsor addressed by my colleague Dr. Peter Atkins. Behind the question there is always an unspoken but never justified implication that since science is unable to answer "Why" questions, there must be some other discipline that is qualified to answer them. This implication is, of course, quite illogical.

I'm afraid that Dr. Atkins gave the Royal Why fairly short shrift. The mere fact that it is possible to frame a question does not make it legitimate or sensible to do so. There are many things about which you can ask, "What is its temperature?" or "What color is it?" but you may not ask the temperature question or the color question of, say, jealousy or prayer. Similarly, you are right to ask the "Why" question of a bicycle's mudguards or the Kariba Dam, but at the very least you have no right to assume that the "Why" question deserves an answer when posed about a boulder, a misfortune, Mt. Everest or the universe. Questions can be simply inappropriate, however heartfelt their framing.

Somewhere between windscreen wipers and tin openers on the one hand and rocks and the universe on the other lie living creatures. Living bodies and their organs are objects that, unlike rocks, seem to have purpose written all over them. Notoriously, of course, the apparent purposefulness of living bodies has dominated the classic Argument from Design, invoked by theologians from Aquinas to William Paley to modern "scientific" creationists.

The true process that has endowed wings and eyes, beaks, nesting instincts and everything else about life with the strong illusion of purposeful design is now well understood. It is Darwinian natural selection. Our understanding of this has come astonishingly recently, in the last century and a half. Before Darwin, even educated people who had abandoned "Why" questions for rocks, streams and eclipses still implicitly accepted the legitimacy of the "Why" question where living creatures were concerned. Now only the scientifically illiterate do. But "only" conceals the unpalatable truth that we are still talking about an absolute majority.

Actually, Darwinians do frame a kind of "Why" question about living things, but they do so in special, metaphorical sense. Why do birds sing, and what are wings for? Such questions would be accepted as a shorthand by modern Darwinians and would be given sensible answers in terms of the natural selection of bird ancestors. The illusion of purpose is so powerful that biologists themselves use the assumption of good design as a working tool. As we saw in the previous chapter, long before his epoch-making work on the bee dance Karl von Frisch discovered, in the teeth of strong orthodox opinion to the contrary, that some insects have true color vision. His clinching experiments were stimulated by the simple observation that bee-pollinated flowers go to great trouble to manufacture colored pigments. Why would they do this if bees were color-blind? The metaphor of purpose-more precisely, the assumption that Darwinian selection is involved-is here being used to make a strong inference about the world. It would have been quite wrong for von Frisch to have said, "Flowers are colored, therefore bees must have color vision." But it was right for him to say, as he did, "Flowers are colored, therefore it is at least worth my while working hard at some new experiments to test the hypothesis that they have color vision." What he found when he looked into the matter in detail was that bees have good color vision but the spectrum they see is shifted relative to ours. They can't see red light (they might give the name "infra yellow" to what we call red). But they can see into the range of shorter wavelengths we call ultraviolet, and they see ultraviolet as a distinct color, sometimes called "bee purple".

When he realized that bees see in the ultraviolet part of the spectrum, von Frisch again did some reasoning using the metaphor of purpose. What, he asked himself, do bees use their ultraviolet sense for? His thought returned full circle-to flowers. Although we can't see ultraviolet light, we can make photographic film that is sensitive to it, and we can make filters that are transparent to ultraviolet light but cut out "visible" light. Acting on his hunch, von Frisch took some ultraviolet photographs of flowers. To his delight, he saw patterns of spots and stripes that no human eye had ever seen before. Flowers that to us look white or yellow are in fact decorated with ultraviolet patterns, which often serve as runway markers to guide the bees to the nectaries. The assumption of apparent purpose had paid off once again: flowers, if they were will designed, would exploit the fact that bees can see ultraviolet wavelengths.

When he was an old man, von Frisch's most famous work-on the dance of the bees, which we discussed in the last chapter-was called into question by an American biologist named Adrian Wenner. Fortunately, von Frisch lived long enough to see his work vindicated by another American, James L. Gould, now at Princeton, in one of the most brilliantly conceived experiments of all biology. I'll briefly tell the story, because it is relevant to my point about the power of the "as if designed" assumption.

Wenner and his colleagues did not deny that the dance happens. They did not even deny that it contains all the information von Frisch said it did. What they did deny is that other bees read the dance. Yes, Wenner said, it is true that the direction of the straight run of the waggle dance relative to the vertical is related to the direction of food relative to the sun. But no, other bees don't receive this information from the dance. Yes, it is true that the rates of various things in the dance can be read as information about the distance of food. But there is no good evidence that the other bees read the information. They could be ignoring it. Von Frisch's evidence, the skeptics said, was flawed, and when they repeated his experiments with proper "controls" (that is, by taking care of alternative means by which bees might find food), the experiments no longer supported von Frisch's dance-language hypothesis.

This was where Jim Gould came into the story with his exquisitely ingenious experiments. Gould exploited a long-known fact about honeybees, which you will remember from the previous chapter. Although they usually dance in the dark, using the straight-up direction in the vertical plane as a coded token of the sun's direction in the horizontal plane, they will effortlessly switch to a possibly more ancestral way of doing things if you turn on a light inside the hive. They then forget all about gravity and use the lightbulb as their token sun, allowing it to determine the angle of the dance directly. Fortunately, no misunderstandings arise when the dancer switches her allegiance from gravity to the lightbulb. The other bees "reading" the dance switch their allegiance in the same way, so the dance still carries the same meaning: the other bees still head off looking for food in the direction the dancer intended.

Now for Jim Gould's masterstroke. He painted a dancing bee's eyes over with black shellac, so that she couldn't see the lightbulb. She therefore danced using the normal gravity convention. But the other bees following her dance, not being blindfolded, could see the lightbulb. They interpreted the dance as if the gravity convention had been dropped and replaced by the lightbulb "sun" convention. The dance followers measured the angle of the dance relative to the light, whereas the dancer herself was aligning it relative to gravity. Gould was, in effect, forcing the dancing bee to lie about the direction of the food. Not just lie in a general sense, but lie in a particular direction that Gould could precisely manipulate. He did the experiment not with just one blindfolded bee, of course, but with a proper statistical sample of bees and variously manipulated angles. And it worked. Von Frisch's original dance-language hypothesis was triumphantly vindicated.

I didn't tell this story for fun. I wanted to make a point about the negative as well as the positive aspects of the assumption of good design. When I first read the skeptical papers of Wenner and his colleagues, I was openly derisive. And this was not a good thing to be, even though Wenner eventually turned out to be wrong. My derision was based entirely on the "good design" assumption. Wenner was not, after all, denying that the dance happened, nor that it embodied all the information von Frisch had claimed about the distance an direction of food. Wenner simply denied that the other bee read the information. And this was too much for me and many other Darwinian biologists to stomach. The dance was so complicated, so richly contrived, so finely tuned to its apparent purpose of informing other bees of the distance and direction of food. This fine tuning could not have come about, in our view, other than by natural selection. In a way, we fell into the same trap as creationists do when they contemplate the wonders of life. The dance simply had to be doing something useful, and this presumably meant helping foragers to find food. Moreover, those very aspects of the dance that were so finely tuned-the relationship of its angle and speed to the direction and distance of food-had to be doing something useful too. Therefore, in our view, Wenner just had to be wrong. So confident was I that, even if I had been ingenious enough to think of Gould's blindfolded experiment (which I certainly wasn't), I would not have bothered to do it.

Gould not only was ingenious enough to think of the experiment but he also bothered to do it, because he was not seduced by the good-design assumption. It is a fine tightrope we are walking, however, because I suspect that Gould-like von Frisch before him, in his color research-had enough of the good-design assumption in his head to believe that his remarkable experiment had a respectable chance of success and was therefore worth spending time and effort on.

I now want to introduce two technical terms, "reverse engineering" and "utility function". In this section, I am influenced by Daniel Dennett's superb book Darwin's Dangerous Idea. Reverse engineering is a technique of reasoning that works like this. You are an engineer, confronted with an artifact you have found and don't understand. You make the working assumption that it was designed for some purpose. You dissect and analyze the object with a view to working out what problem it would be good at solving: "If I had wanted to make a machine to do so-and-so, would I have made it like this? Or is the object better explained as a machine designed to do such-and-such?"

The slide rule, talisman until recently of the honorable profession of engineer, is in the electronic age as obsolete as any Bronze Age relic. An archaeologist of the future, finding a slide rule and wondering about it, might note that it is handy for drawing straight lines or for buttering bread. But to assume that either of these was its original purpose violates the economy assumption. A mere straight-edge or butter knife would not have needed a sliding member in the middle of the rule. Moreover, if you examine the spacing of the graticules you find precise logarithmic scales, too meticulously disposed to be accidental. It would dawn on the archaeologist that, in an age before electronic calculators, this pattern would constitute an ingenious trick for rapid multiplication and division. The mystery of the slide rule would be solved by reverse engineering, employing the assumption of intelligent and economical design.

"Utility function" is a technical term not of engineers but of economists. It means "that which is maximized." Economic planners and social engineers are rather like architects and real engineers in that they strive to maximize something. Utilitarians strive to maximize "the greatest happiness for the greatest number" (a phrase that sounds more intelligent than it is, by the way). Under this umbrella, the utilitarian may give long-term stability more or less priority at the expense of short-term happiness, and utilitarians differ over whether they measure "happiness" by monetary wealth, job satisfaction, cultural fulfillment or personal relationships. Others avowedly maximize their own happiness at the expense of the common welfare, and they may dignify their egoism by a philosophy that states that general happiness will be maximized if one takes care of oneself. By watching the behavior of individuals throughout their lives, you should be able to reverse-engineer their utility functions. If you reverse-engineer the behavior of a country's government, you may conclude that what is being maximized is employment and universal welfare. For another country, the utility function may turn out to be the continued power of the president, or the wealth of a particular ruling family, the size of the sultan's harem, the stability of the Middle East or maintaining the price of oil. The point is that more than one utility function can be imagined. It isn't always obvious what individuals, or firms, or governments are striving to maximize. But it is probably safe to assume that they are maximizing something. This is because Homo sapiens is a deeply purpose-ridden species. The principle holds good even if the utility function turns out to be a weighted sum or some other complicated function of many inputs.

Let us return to living bodies and try to extract their utility function. There could be many but, revealingly, it will eventually turn out that they all reduce to one. A good way to dramatize our task is to imagine that living creatures were made by a Divine Engineer and try to work out, by reverse engineering, what the Engineer was trying to maximize: What was God's Utility Function?

Cheetahs give every indication of being superbly designed for something, and it should be easy enough to reverse-engineer them and work out their utility function. They appear to be well designed to kill antelopes. The teeth, claws, eyes, nose, leg muscles, backbone and brain of a cheetah are all precisely what we should expect if God's purpose in designing cheetahs was to maximize deaths among antelopes. Conversely, if we reverse-engineer an antelope we find equally impressive evidence of design for precisely the opposite end: the survival of antelopes and starvation among cheetahs. It is as though cheetahs had been designed by one deity and antelopes by a rival deity. Alternatively, if there is only one Creator who made the tiger and the lamb, the cheetah and the gazelle, what is He playing at? Is He a sadist who enjoys spectator blood sports? Is He trying to avoid overpopulation in the mammals of Africa? Is He maneuvering to maximize David Attenborough's television ratings? These are all intelligible utility functions that might have turned out to be true. In fact, of course, they are all completely wrong. We now understand the single Utility Function of life in great detail, and it is nothing like any of those.

Chapter 1 will have prepared the reader for the view that the true utility function of life, that which is being maximized in the natural world, is DNA survival. But DNA is not floating free; it is locked up in living bodies and it has to make the most of the levers of power at its disposal. DNA sequences that find themselves in cheetah bodies maximize their survival by causing those bodies to kill gazelles. Sequences that find themselves in gazelle bodies maximize their survival by promoting opposite ends. But it is DNA survival that is being maximized in both cases. In this chapter, I am going to do a reverse-engineering job on a number of practical examples and show how everything makes sense once you assume that DNA survival is what is being maximized.

The sex ratio-the proportion of males to females-in wild populations is usually 50:50. This seems to make no economic sense in those many species in which a minority of males has an unfair monopoly of the females: the harem system. In one well-studied population of elephant seals, 4 percent of the males accounted for 88 percent of all the copulations. Never mind that God's Utility Function in this case seems so unfair for the bachelor majority. What is worse, a cost-cutting, efficiency-minded deity would be bound to spot that the deprived 96 percent are consuming half the population's food resources (actually more than half, because adult male elephant seals are much bigger than females). The surplus bachelors do nothing except wait for an opportunity to displace one of the lucky 4 percent of harem masters. How can the existence of these unconscionable bachelor herds possibly be justified? Any utility function that paid even a little attention to the economic efficiency of the community would dispense with the bachelors. Instead, there would bee just enough males born to fertilize the females. This apparent anomaly, again, is explained with elegant simplicity once you understand the true Darwinian Utility Function: maximize DNA survival.

I’ll go into the example of the sex ratio in a little detail, because its utility function lends itself subtly to an economic treatment. Charles Darwin confessed himself baffled: “I formerly thought that when a tendency to produce the two sexes in equal numbers was advantageous to the species, it would follow from natural selection, but I now see that the whole problem is so intricate that it is safer to leave its solution for the future.” As so often, it was the great Sir Ronald Fisher who stood up in Darwin’s future. Fisher reasoned as follows.

All individuals born have exactly one mother and one father. Therefore the total reproductive success, measured in distant descendants, of all males alive must equal that of all females alive. I don’t mean of each male and female, because some individuals clearly, and importantly, have more success than others. I am talking about the totality of males compared with the totality of females. This total posterity must be divided up between the individual males and females-not divided equally, but divided. The reproductive cake that must be divided among all males is equal to the cake that must be divided among all females. Therefore if there are, say, more males than females in the population, the average slice of cake per male must be smaller than the average slice of cake per female. It follows that the average reproductive success (that is, the expected number of descendants) of a male compared with the average reproductive success of a female is solely determined by the male-female ratio. An average member of the minority sex has a greater reproductive success than an average member of the majority sex. Only if the sex ratio is even and there is no minority will the sexes enjoy equal reproductive success. This remarkably simple conclusion is a consequence of pure armchair logic. It doesn’t depend on any empirical facts at all, except the fundamental fact that all children born have one father and one mother.

Sex is usually determined at conception, so we may assume that an individual has no power to determine his or her (for once the circumlocution is not ritual but necessary) sex. We shall assume, with Fisher, that a parent might have power to determine the sex of its offspring. By “power”, of course, we don’t mean power consciously or deliberately wielded. But a mother might have a genetic predisposition to generate a vaginal chemistry slightly hostile to son-producing but not to daughter-producing sperms. Or a father might have a genetic tendency to manufacture more daughter-producing sperms than son-producing sperms. However it might in practice be done, imagine yourself as a parent trying to decide whether to have a son or a daughter. Again, we are not talking about conscious decisions but about the selection of generations of genes acting on bodies to influence the sex of their offspring.

If you were trying to maximize the number of your grandchildren, should you have a son or a daughter? We have already seen that you should have a child of whichever sex is in the minority in the population. That way, your child can expect a relatively large share of reproductive activity and you can expect a relatively large number of grandchildren. If neither sex is rarer that the other-if, in other words, the ratio is already 50:50-you cannot benefit by preferring one sex or the other. It doesn’t matter whether you have a son or a daughter. A 50:50 sex ratio is therefore referred to as evolutionarily stable, using the term coined by the great British evolutionist John Maynard Smith. Only if the existing sex ratio is something other than 50:50 does a bias in you r choice pay. As for the question of why individuals should try to maximize their grandchildren and later descendants, it will hardly need asking. Genes that cause individuals to maximize their descendants are the genes we expect to see in the world. The animals we are looking at inherit the genes of successful ancestors.

It is tempting to express Fisher’s theory by saying that 50:50 is the “optimum” sex ratio, but this is strictly incorrect. The optimum sex to choose for a child is male if males are in a minority, female if females are in a minority. If neither sex is in a minority, there is no optimum: the well-designed parent is strictly indifferent about whether a son or a daughter will be born. Fifty-fifty is said to be the evolutionarily stable sex ratio because natural selection does not favor any tendency to deviate from it, and if there is any deviation from it natural selection favors a tendency to redress the balance.

Moreover, Fisher realized that it isn't strictly the numbers of males and females that are held at 50:50 by natural selection, but what he called the "parental expenditure" on sons and daughters. Parental expenditure means all the hard-won food poured into the mouth of a child; and all the time and energy spent looking after it, which could have been spent doing something else, such as looking after another child. Suppose, for instance, that parents in a particular seal species typically spend twice as much time and energy on rearing a son as on rearing a daughter. Bull seals are so massive compared with cows that it is easy to believe (though probably inaccurate in fact) that this might be the case. Think what it would mean. The true choice open to the parent is not "Should I have a son or a daughter?" but "Should I have a son or two daughters?" The evolutionarily stable sex ratio, measured in numbers of bodies, would then be two females to every male. But measured in amounts of parental expenditure (as opposed to numbers of individuals), the evolutionarily stable sex ratio is still 50:50. Fisher's theory amounts to a balancing of the expenditures on the two sexes. This often, as it happens, turns out to be the same as balancing the numbers of the two sexes.

Even in seals, as I said, it looks as though the amount of parental expenditure on sons is not noticeably different from the amount spent on daughters. The massive inequality in weight seems to come about after the end of parental expenditure. So the decision facing a parent is still "Should I have a son or a daughter?" Even thought the total cost of a son's growth to adulthood may be much more than the total cost of a daughter's growth, if the additional cost is not borne by the decision maker (the parent) that's all that counts in Fisher's theory.

Fisher's rule about balancing the expenditure still holds in those cases where one sex suffers a higher rate of mortality than the other. Suppose, for instance, that male babies are more likely to die than female babies. If the sex ratio at conception is exactly 50:50, the males reaching adulthood will be outnumbered by the females. They are therefore the minority sex, and we'd naively expect natural selection to favor parents that specialize in sons. Fisher would expect this too, but only up to a point-and a precisely limited point, at that. He would not expect parents to conceive such a surplus of sons that the greater infant mortality is exactly compensated, leading to equality in the breeding population. No, the sex ratio at conception should be somewhat male-biased, but only up to the point where the total expenditure on sons is expected to equal the total expenditure on daughters.

Once again, the easiest way to think about it is to put yourself in the position of the decision-making parent and ask the question "Should I have a daughter, who will probably survive, or a son, who may die in infancy?" The decision to make grandchildren via sons entails a probability that you'll have to spend more resources on some extra sons to replace those that are going to die. You can think of each surviving son as carrying the ghosts of his dead brothers on his back. He carries them on his back in the sense that the decision to go the son route to grandchildren lets the parent in for some additional wasted expenditure-expenditure that will be squandered on dead infant males. Fisher's fundamental rule still holds good. The total amount of goods and energy invested in sons (including feeding infant sons up to the point where they died will equal the total amount invested in daughters.

What if, instead of higher male infant mortality, there is higher male mortality after the end of parental expenditure? In fact this will often be so, because adult males often fight and injure each other. This circumstance, too, will lead to a surplus of females in the breeding population. On the face of it, therefore, it would seen to favor parents who specialize in sons, thereby taking advantage of the rarity of males in the breeding population. Think a little harder, however, and you realize that the reasoning is fallacious. The decision facing a parent is the following: “Should I have a son, who will likely be killed in battle after I’ve finished rearing him but who, if he survives, will give me extra specially many grandchildren? Or shall I have a daughter, who is fairly certain to give me an average number grandchildren?” The number of grandchildren you can expect through a son is still the same as the average number you can expect through a daughter. And the cost of making a son is still the cost of feeding and protecting him up to the moment when he leaves the nest. The fact that he is likely to get killed soon after he leaves the nest does not change the calculation.

In all this reasoning, Fisher assumed that the “decision maker” is the parent. The calculation changes if it is somebody else. Suppose, for instance, that an individual could influence its own sex. Once again, I don’t mean influence by conscious intention. I am hypothesizing genes that switch an individual’s development into the female or the male pathway, conditional upon cues from the environment. Following our usual convention, for brevity I shall use the language of deliberate choice by an individual-in this case, deliberate choice of its own sex. If harem-based animals like elephant seals were granted this power of flexible choice, the effect would be dramatic. Individuals would aspire to be harem-holding males, but if they failed at acquiring a harem they would much prefer to be females than bachelor males. The sex ratio in the population would become strongly female-biased. Elephant seals unfortunately can’t reconsider the sex they were given at conception, but some fish can. Males of the blue-headed wrasse are large and bright-colored, and they hold harems of dull-colored females. Some females are larger than others, and they form a dominance hierarchy. If a male dies his place is quickly taken by the largest female, who soon turns into a bright-colored male. These fish get the best of both worlds. Instead of wasting their lives as bachelor males waiting for the death of a dominant, harem-holding male, they spend their waiting time as productive females. The blue-headed wrasse sex-ratio system is a rare one, in which God’s Utility Function coincides with something that a social economist might regard as prudent.

So, we’ve considered both the parent and the self as decision maker. Who else might the decision maker be? In the social insects the investment decisions are made, in large part, by sterile workers, who will normally be elder sisters (and also brothers, in the case of termites) of the young being reared. Among the more familiar social insects are honeybees. Beekeepers among my readers may already have recognized that the sex ratio in the hive doesn’t seem, on the face of it, to conform to Fisher’s expectations. The first thing to note is that workers should not be counted as females. They are technically females, but they don’t reproduce, so the sex ratio being regulated according to Fisher’s theory is the ratio of drones (males) to new queens being churned out by the hive. In the case of bees and ants, there are special technical reasons, which I have discussed in The Selfish Gene and won’t rehearse here, for expecting the sex ratio to be 3:1 in favor of females. Far from this, as any beekeeper knows, the actual sex ratio is heavily male-biased. A flourishing hive may produce half a dozen new queens in a season but hundreds or even thousands of drones.

What is going on here? As so often in modern evolutionary theory, we owe the answer to W.D. Hamilton, now at Oxford University. It is reveling and epitomizes the whole Fisher-inspired theory of sex ratios. The key to the riddle of bee sex ratios lies in the remarkable phenomenon of swarming. A beehive is, in many ways, like a single individual. It grows to maturity, it reproduces, and eventually it dies. The reproductive product of a beehive is a swarm. At the height of summer, when a hive has been really prospering, it throws off a daughter colony-a swarm. Producing swarms is the equivalent of reproduction, for the hive. If the hive is a factory, swarms are the end product, carrying with them the precious genes of the colony. A swarm comprises one queen and several thousand workers. They all leave the parent hive in a body and gather as a dense cluster, hanging from a bough or a rock. This will be their temporary encampment while they prospect for a new permanent home. Within a few days, they find a cave or a hollow tree (or, more usually nowadays, they are captured by a beekeeper, perhaps the original one, and housed in a new hive).

It is the business of a prosperous hive to throw off daughter swarms. The first step in doing this is to make a new queen. Usually half a dozen or so new queens are made, only one of whom is destined to live. The first one to hatch stings all the others to death. (Presumably the surplus queens are there only for insurance purposes.) Queens are genetically interchangeable with workers, but they are reared in special queen cells that hang below the comb, and they are fed on a specially rich, queen-nourishing diet. This diet includes royal jelly, the substance to which the novelist Dame Barbara Cartland romantically attributes her long life and queenly deportment. Worker bees are reared in smaller cells, the same cells that are later used to store honey. Drones are genetically different. They come from unfertilized eggs. Remarkably, it is up to the queen whether an egg turns into a drone or into female (queen/worker). A queen bee mates only during a single mating flight, at the beginning of her adult life, and she stores the sperm for the rest of her life, inside her body. As each egg passes down her egg tube, she may or may not release a small package of sperm from her store, to fertilize it. Subsequently, however, the workers seem to have all the power, because they control the food supply for the larvae. They could, for instance, starve male larvae if the queen laid too many (from their point of view) male eggs. In any case the workers have control over whether a female egg turns into a worker or a queen, since this depends solely on rearing conditions, especially diet.

Now let’s return to our sex-ratio problem and look at the decision facing the workers. As we have seen, unlike the queen, they are not choosing whether to produce sons or daughters but whether to produce brothers (drones) or sisters (young queens). And now we are back to our riddle. For the actual sex ratio seems to be massively male-biased, which doesn’t seen to make sense from Fisher’s point of view. Let’s look harder at the decision facing the workers. I said that it was a choice between brothers and sisters. But wait a moment. The decision facing the workers. I said that it was a choice between brothers and sisters. But wait a moment. The decision to rear a brother is, indeed, just that: it commits the hive to whatever food and other resources it takes to rear one drone bee. But the decision to rear a new queen commits the hive to far more than just the resources needed to nourish one queen’s body. The decision to rear a new queen is tantamount to a commitment to lay down a swarm. The true cost of a new queen only negligibly includes the small amount of royal jelly and other food that she will eat. It mostly consists of the cost of making all the thousands of workers who are going to be lost to the hive when the swarm departs.

This is almost certainly the true explanation for the apparently anomalous male bias in the sex ratio. It turns out to be an extreme example of what I was talking about earlier. Fisher’s rule states that the quantity of expenditure on males and females must be equal, not the census count of male and female individuals. The expenditure on a new queen entails massive expenditure on workers who would not otherwise have been lost to the hive. It is like our hypothetical seal population, in which one sex costs twice as much as the other to rear, with the result that that sex is half as numerous. In the case of bees a queen costs hundreds or even thousands of times as much as a drone, because she carries on her back the cost of all the extra workers needed for the swarm. Therefore queens are hundreds of times less numerous than drones. There is an additional sting to this curious tale: when a swarm leaves, it mysteriously contains the old queen, not the new one. Nevertheless, the economics are the same. The decision to make a new queen still entails the outlay of the swarm needed to escort the old queen to her new home.

To round off our treatment of sex ratios, we return to the riddle of the harems with which we began: that profligate arrangement whereby a large herd of bachelor males consumes nearly half (or even more than half) the population's food resources but never reproduces nor does anything else useful. Obviously the economic welfare of the population is not being maximized here. What is going on? Once again, put yourself in the position of the decision maker-say, a mother trying to “decide” whither to have a son or a daughter in order to maximize the number of her grandchildren. Her decision is, at naпve first sight, an unequal one: “Should I have a son, who will probably end up a bachelor and give me no grandchildren at all, or a daughter, who will probably end up in a harem and will give me a respectable number of grandchildren?” The proper reply to this would be parent is “But if you have a son, he may end up with a harem, in which case he'll give you far more grandchildren than you could ever hope to get via daughter.” Suppose, for simplicity, that all the females reproduce at the average rate, and that nine out of ten males never reproduce, while one male in ten monopolizes the females. If you have a daughter, you can count on an average number of grandchildren. If you have a son, you have a 90 percent chance of no grandchildren but a 10 percent chance of having ten times the average number of grandchildren. The average number of grandchildren you can expect through your sons is the same as the average number you can expect through your daughters. Natural selection still favors 50:50 sex ratio, even though species-level economic reason cries out for a surplus of females. Fisher's rule still holds.

I expressed all these reasonings in terms of “decisions” of individual animals but, to repeats, this is just shorthand. What is really going on is that “for” maximizing grandchildren become more numerous in the gene pool. The world becomes full of genes that have successfully come down the ages. How should a gene be successful in coming sown the ages other than by influencing the decisions of individuals so as to maximize their numbers of descendants? Fisher's sex-ratio theory tells us how this maximizing should be done, and it is very different from maximizing the economic welfare of the species or population. There is a utility function here, but it is far from the utility function that would spring to our human economic minds.

The wastefulness of the harem economy can be summarized as follows: Males, instead of devoting themselves to useful work, squander their energy and strength in futile struggles against one another. This is true, even if we define “useful” in an apparently Darwinian way, as concerned with rearing children. If males diverted into useful channels the energy that they waste competing with each other, the species as a whole would rear more children for less effort and less food consumed.

A work-study expert would stare aghast at the world of the elephant seal. An approximate parallel would be the following. A workshop needs no more than ten men to run it, since there are just ten lathes in the workshop. Instead of simply employing ten men, the management decides to employ a hundred men. Every day, all hundred men turn up and collect their wages. Then they spend the day fighting for possession of the ten lathes. Some items get made on the lathes, but no more than would have been achieved by ten men, and probably fewer, because the hundred men are so busy fighting that the lathes are not being used efficiently. The work-study expert would e in no doubt. Ninety percent of the men are redundant, and they should be officially declared so and dismissed.

It isn't just in physical combat that male animals waste their efforts-“waste” being defined, once again, from the point of view of the human economist or work-study expert. In many species there's a beauty contest too. This brings us to another utility function that we humans can appreciate even though it doesn't make straightforward economic sense: aesthetic beauty. On the face of it, it might look as though God's Utility Function is sometimes drawn up along the lines of the (now thankfully unfashionable) Miss World contest, but with males parading the runway. This is seen most clearly in the so-called leks of birds such as grouse and ruffs. A “lek” is a patch of ground traditionally used by male birds for parading in front of females. Females visit the lek and watch the swaggering displays of a number of males before singling one out and copulating with him. The males of lekking species often have bizarre ornamentation, which they show off with equally remarkable bowing or bobbing movements and strange noises. The word “bizarre” is, of course, a subjective value judgment; presumably lekking males sage grouse, with their puffed-up dances accompanied by cork-popping noises, don’t seem bizarre to the females of their own species, and this is all that matters. In some cases the female birds’ idea of beauty happens to coincide with ours, and the result is a peacock or a bird of paradise.

Nightingale songs, pheasant tails, firefly flashes and the rainbow scales of tropical reef fish are all maximizing aesthetic beauty, but it is not-or is only incidentally-beauty for human delectation. If we enjoy the spectacle it is a bonus, a by-product. Genes that make males attractive to females automatically find themselves passed down the digital river to the future. There is only one utility function that makes sense of these beauties; it is the same one that explains elephant-seal sex ratios, cheetahs and antelopes running superficially futile races against each other, cuckoos and lice, eyes and ears and windpipes, sterile worker ants and superfertile queens. The great universal Utility Function, the quantity that is being diligently maximized in every cranny of the living world is, in every case, the survival of the DNA responsible for the feature you are trying to explain.

Peacocks are burdened with finery so heavy and cumbersome that it would gravely hamper their efforts to do useful work, even if they felt inclined to do useful work-which, on the whole, they don’t. Male songbirds use dangerous amounts of time and energy singing. This certainly imperils them, not only because it attract predators but because it drains energy and uses time that could be spent replenishing that energy. A student of wren biology claimed that one of his wild males sang itself literally to death. Any utility function that had the long-term welfare of the species at heart, even the long-term survival of this particular individual male, would cut down on the amount of singing, the amount of displaying, the amount of fighting among males. Yet, because what is really being maximized is DNA survival, nothing can stop the spread of DNA that has no beneficial effect other than making males beautiful to females. Beauty is not an absolute virtue in itself. But inevitably, if some genes do confer on males whatever qualities the females of the species happen to find desirable, those genes, willy-nilly, will survive.

Why are forest trees so tall? Simply to overtop rival trees. A “sensible” utility function would see to it that they were all short. They would get exactly the same amount of sunlight, with far less expenditure on thick trucks and massive supporting buttresses. But if they were all short, natural selection couldn’t help favoring a variant individual that grew a little taller. The ante having been upped, others would have to follow suit. Nothing can stop the whole game escalating until all trees are ludicrously and wastefully tall. It is ludicrous and wasteful only from the point of view of a rational economic planner thing s in terms of maximizing efficiency. But it all makes sense once you understand the true utility function-genes are maximizing their own survival. Homely analogies abound. At a cocktail party, you shout yourself hoarse. The reason is that everybody else is shouting at top volume. If only the guests could come to an agreement to whisper, they’d hear one another exactly as well with less voice strain and less expenditure of energy. But agreements like that don’t work unless they are policed. Somebody always spoils it by selfishly talking a bit louder, and, one by one, everybody has to follow suit. A stable equilibrium is reached only when everybody is shouting as loudly as physically possible, and this is much louder than required from a “rational” point of view. Time and again, cooperative restraint is thwarted by its own internal instability. God’s Utility Function seldom turns out to be the greatest good for the greatest number. God’s Utility Function betrays its origins in an uncoordinated scramble for selfish gain.

Humans have a rather endearing tendency to assume that welfare means group welfare, that "good" means the good of society, the future well-being of the species or even of the ecosystem. God's Utility Function, as derived from a contemplation of the nuts and bolts of natural selection, turns out to be sadly at odds with such utopian visions. To be sure, there are occasions when genes may maximize their selfish welfare at their level, by programming unselfish cooperation, or even self-sacrifice, by the organism at its level. But group welfare is always a fortuitous consequence, not a primary drive. This is the meaning of "the selfish gene".

Let us look at another aspect of God's Utility Function, beginning with an analogy. The Darwinian psychologist Nicholas Humphrey made up an illuminating fact about Henry Ford. "It is said" that Ford, the patron saint of manufacturing efficiency, once

commissioned a survey of the car scrapyards of America to find out if there were parts of the Model T Ford which never failed. His inspectors came back with reports of almost every kind of breakdown: axles, brakes, pistons-all were liable to go wrong. But they drew attention to one notable exception, the kingpins of the scrapped cars invariably had years of life left in them. With ruthless logic Ford concluded that the kingpins on the Model T were too good for their job and ordered that in future they should be made to an inferior specification.

You may, like me, be a little vague about what kingpins are, but it doesn't matter. They are something that a motor car needs, and Ford's alleged ruthlessness was, indeed, entirely logical. The alternative would have been to improve all the other bits of the car to bring them up to the standard of the kingpins. But then it wouldn't have been a Model T he was manufacturing but a Rolls Royce, and that wasn't the object of the exercise. A Rolls Royce is a respectable car to manufacture and so is a Model T, but for a different price. The trick is to make sure that either the whole car is built to Rolls Royce specifications or the whole car is built to Model T specifications. If you make a hybrid car, with some components of Model T quality and some components of Rolls Royce quality, you are getting the worst of both worlds, for the car will be thrown away when the weakest of its components wears out, and the money spent on high-quality components that never get time to wear out is simply wasted.

Ford's lesson applies even more strongly to living bodies than to cars, because the components of a car can, within limits, be replaced by spares. Monkeys and gibbons make their living in the treetops and there is always a risk of falling and breaking bones. Suppose we commissioned a survey of monkey corpses to count the frequency of breakage in each major bone of the body. Suppose it turned out that every bone breaks at some time or another, with one exception: the fibula (the bone that runs parallel to the shinbone) has never ever been observed to break in any monkey. Henry Ford's unhesitating prescription would be to redesign the fibula to an inferior specification, and this is exactly what natural selection would do too. Mutant individuals with an inferior fibula-mutant individuals whose growth rules call for diverting precious calcium away from the fibula-could use the material saved to thicken other bones in the body and so achieve the ideal of making every bone equally likely to break. Or the mutant individuals could use the calcium saved to make more milk and so rear more young. Bone can safely be shaved off the fibula, at least up to the point where it becomes as likely to break as the next most durable bone. The alternative-the "Rolls Royce" solution of bringing all the other components up to the standard of the fibula-is harder to achieve.

The calculation isn't quiet as simple as this, because some bones are more important than others. I guess it is easier for a spider monkey to survive with a fractured heelbone than with a fractured armbone, so we should not literally expect natural selection to make all bones equally likely to break. But the main lesson we take away from the legend of Henry Ford is undoubtedly correct. It is possible for a component of an animal to be too good, and we should expect natural selection to favor a lessening of quality up to, but not beyond, a point of balance with the quality of the other components of the body. More precisely, natural selection will favor a leveling out of quality in both the downward and upward directions, until a proper balance is struck over all parts of the body.

It is especially easy to appreciate this balance when it is struck between two rather separate aspects of life: peacock survival versus beauty in the eyes of peahens, for instance. Darwinian theory tells us that all survival is just a means to the end of gene propagation, but this does not stop us partitioning the body into those components, like legs, that are primarily concerned with individual survival and those, like penises, that are concerned with reproduction. Or those, like antlers, that are devoted to competing with rival individuals versus those, like legs and penises, whose importance does not depend upon the existence of rival individuals. Many insects impose a rigid separation between radically different stages in their life history. Caterpillars are devoted to gathering food and growing. Butterflies are like the flowers they visit, devoted to reproducing. They do not grow, and they suck nectar only to burn it immediately as aviation fuel. When a butterfly reproduces successfully, it spreads the genes not just for being an efficient flying and mating butterfly but for being the efficient feeding caterpillar that it was, as well. Mayflies feed and grow as underwater nymphs for up to three years. They then emerge as flying adults that live only a matter of hours. Many of them are eaten by fish, but even if they were not they would soon die anyway, because they cannot feed and they do not even possess guts (Henry Ford would have loved them). Their job is to fly until they find a mate. Then, having passed on their genes-including the genes for being an efficient nymph capable of feeding underwater for three years-they die. A mayfly is like a tree that takes years to grow, then flowers for a single glorious day and dies. The adult mayfly is the flower that briefly blooms at the end of life and the beginning of new life.

A young salmon migrates down the stream of its birth and spends the bulk of its life feeding and growing in the sea. When it reaches maturity it again seeks out, probably by smell, the mouth of its native stream. In an epic and much-celebrated journey the salmon swims upstream, leaping falls and rapids, home to the headwaters from which it sprang a lifetime ago. There it spawns and the cycle renews. At this point there is typically a difference between Atlantic and Pacific salmon. The Atlantic salmon, having spawned, may return to the sea with some chance of repeating the cycle a second time. Pacific salmon die, spent, within days of spawning.

A typical Pacific salmon is like a mayfly but without the anatomically clear-cut separation between nymph and adult phases in the life history. The effort of swimming upstream is so great that it cannot pay to do it twice. Therefore natural selection favors individuals that put every ounce of their resources into one “big bang” reproductive effort. Any resources left after breeding would be wasted-the equivalent of Henry Ford’s overdesigned kingpins. The Pacific salmon have evolved toward whittling down their postreproductive survival until it approaches zero, the resources saved being diverted into eggs or milt. The Atlantic salmon were drawn toward the other route. Perhaps because the rivers they have to mount tend to be shorter and spring from less formidable hills, individuals that keep some resources back for a second reproductive cycle can sometimes do well by it. The price these Atlantic salmon pay is that they cannot commit so much to their spawn. There is a trade-off between longevity and reproduction, and different kinds of salmon have opted for different equilibria. The special feature of the salmon life cycle is that the grueling odyssey of their migration imposes a discontinuity. There is no easy continuum between one breeding season and two. Commitment to a second breeding season drastically cuts into efficiency in the first. Pacific salmon have evolved toward an unequivocal commitment to the first breeding season, with the result that a typical individual unequivocally dies immediately after its single titanic spawning effort.

The same kind of trade-off marks every life, but it is usually less dramatic. Our own death is probably programmed in something like the same sense as that of the salmon but in a less downright and clear-cut fashion. Doubtless a eugenicist could breed a race of superlatively long-lived humans. You would choose for breeding those individuals who put most of their resources into their own bodies at the expense of their children: individuals, for example, whose bones are massively reinforced and hard to break but who have little calcium left over to make milk. It is easy enough to live a bit longer, if you are cosseted at the expense of the next generation. The eugenicist could do the cosseting and exploit the trade-offs in the desired direction of longevity. Nature will not cosset in this way, because genes for scrimping the next generation will not penetrate the future.

Nature's Utility Function never values longevity for its own sake but only for the sake of future reproduction. Any animal that, like us but unlike a Pacific salmon, breeds more than once faces trade-offs between the current child (or litter) and future children. A rabbit that devoted all her energy and resources to her first litter would probably have a superior first litter. But she would have no resources left to carry her on to a second litter. Genes for keeping something in reserve will tend to spread through the rabbit population, carried in the bodies of second- and third-litter babies. It is genes of this kind that so conspicuously did not spread through the population of Pacific salmon, because the practical discontinuity between one breeding season and two is so formidable.

As we grow older our chances of dying within the next year, after initially decreasing and then plateauing for a while, settle down to a long climb. What is happening in this long increase in mortality? It is basically the same principle as for the Pacific salmon, but spread out over an extended period instead of being concentrated in a brief precipitous orgy of death after the orgy of spawning. The principle of how senescence evolved was originally worked out the Nobel laureate and medical scientist Sir Peter Medawar in the early 1950's, with various modifications to the basic idea added by the distinguished Darwinian G.C. Williams and W.D. Hamilton.

The essential argument is as follows: First, as we saw in chapter 1, any genetic effect will normally be switched on at a particular time during the life of the organism. Many genes are switched on in the early embryo, but others-like the gene for Huntington's chorea, the disease that tragically killed the folk poet and singer Woody Guthrie-are not switched on until middle age. Second, the details of a genetic effect, including the time at which it is switched on, may be modified by other genes. A man possessing the Huntington's chorea gene can expect to die from the disease, but whether it kills him when he is forty or when he is fifty-five (as Woody Guthrie was) may be influenced by other genes. It follows that by selection of "modifier" genes the time of action of a particular gene can either be postponed or brought forward in evolutionary time.

A gene like the Huntington's chorea gene, which switches on between the ages of thirty-five and fifty-five, has plenty of opportunity to be passed on to the next generation before it kills its possessor. If, however, it were switched on at the age of twenty, it would be passed on only by people who reproduce rather young, and therefore it would be strongly selected against. If it were switched on at the age of ten, it would essentially never be passed on. Natural selection would favor any modifier genes that had the effect of postponing the age of switching on of the Huntington's chorea gene. According to the Medawar/Williams theory, this would be exactly why it normally does not switch on until middle age. Once upon a time it may well have been an early maturing gene, but natural selection has favored a postponing of its lethal effect until middle age. No doubt there is still slight selection pressure to push it on into old age, but this pressure is weak because so few victims die before reproducing and passing the gene on.

The Huntington's chorea gene is a particularly clear example of a lethal gene. There are lots of genes that are not in themselves lethal but nevertheless have effects that increase the probability of dying from some other cause and are called sublethal. Once again, their time of switching on may be influenced by modifier genes and therefore postponed or accelerated by natural selection. Medawar realized that the debilities of old age might represent an accumulation of lethal and sublethal genetic effects that had been pushed later and later in the life cycle and allowed to slip through the reproductive net into future generations simply because they were late-acting.

The twist that G.C. Williams, the doyen of modern American Darwinists, gave to the story in 1957 is an important one. It gets back to our point about economic trade-offs. To understand it, we need to throw in a couple of additional background facts. A gene usually has more than one effect, often on parts of the body that are superficially quite distinct. Not only is this "pleiotropy" a fact, it is also very much to be expected, given that genes exert their effects on embryonic development and embryonic development is a complicated process. SO, any new mutation is likely to have not just one effect but several. Though one of its effects may be beneficial, it is unlikely that more than one will be. This is simply because most mutational effects are bad. In addition to being a fact, this is to be expected in principle: if you start with a complicated working mechanism-like a radio, say-there are many more ways of making it worse than of making it better.

Whenever natural selection favors a gene because of its beneficial effect in youth-say, on sexual attractiveness in a young male-there is likely to be a downside: some particular disease in middle or old age, for example. Theoretically, the age effects could be the other way around but, following the Medawar logic, natural selection is hardly going to favor diseases in the young because of a beneficial effect of the same gene in old age. Moreover, we can invoke the point about modifier genes again. Each of the several effects of a gene, its good and its bad effects, could have their switch-on times altered in subsequent evolution. According to the Medawar principle, the good effects would tend to be moved earlier in life, while the bad effects would tend to be postponed until later. Moreover, there will in some cases be a direct trade-off between early and late effects. This was implied in our discussion of salmon. If an animal has a finite quantity of resources to spend on, say, becoming physically strong and able to leap out of danger, any predilection to spend those resources early will be favored over a preference to spend them late. Late spenders are more likely to be already dead from other causes before they have a chance to spend their resources. To put the general Medawar point in a sort of back-to-front version of the language we introduced in chapter 1, everybody is descended from an unbroken line of ancestors all of whom were at some time in their lives young but many of whom were never old. So we inherit whatever it takes to be young, but not necessarily whatever it takes to be old. We tend to inherit genes for dying a long time after we're born, but not for dying a short time after we're born.

To return to this chapter's pessimistic beginning, when the utility function-that which is being maximized-is DNA survival, this is not a recipe for happiness. So long as DNA is passed on, it does not matter who or what gets hurt in the process. It is better for the genes of Darwin's ichneumon wasp that the caterpillar should be alive, and therefore fresh, when it is eaten, no matter what the cost in suffering. Genes don't care about suffering, because they don't car about anything.

If Nature were kind, she would at least make the minor concession of anesthetizing caterpillars before they are eaten alive from within. But Nature is neither kind nor unkind. She is neither against suffering nor for it. Nature is not interest one way or the other is suffering, unless it affects the survival of DNA. It is easy to imagine a gene that, say, tranquilizes gazelles when they are about to suffer a killing bite. Would such a gene be favored by natural selection? Not unless the act of tranquilizing a gazelle improved that gene's chances of being propagated into future generations. It is hard to see why this should be so, and we may therefore guess that gazelles suffer horrible pain and fear when they are pursued to the death-as most of them eventually are. The total amount of suffering per year in the natural world is beyond all decent contemplation. During the minute it takes me to compose this sentence, thousands of animals are being eaten alive; others are running for their lives, whimpering with fear; others are being slowly devoured from within by rasping parasites; thousands of all kinds are dying of starvation, thirst and disease. It must be so. If there is ever a time of plenty, this very fact will automatically lead to an increase in population until the natural state of starvation and misery is restored.

Theologians worry away at the "problem of evil" and a related "problem of suffering". On the day I originally wrote this paragraph, the British newspapers all carried a terrible story about a bus full of children from a Roman Catholic school that crashed for no obvious reason, with wholesale loss of life. Not for the first time, clerics were in paroxysms over the theological question that a writer on a London newspaper (The Sunday Telegraph) framed this way: "How can you believe in a loving, all-powerful God who allows such a tragedy?" The article went on to quote one priest's reply: "The simple answer is that we do not know why there should be a God who lets these awful things happen. But the horror of the crash, to a Christian, confirms the fact that we live in a world of real values: positive and negative. If the universe was just electrons, there would be no problem of evil or suffering."

On the contrary, if the universe were just electrons and selfish genes, meaningless tragedies like the crashing of this bus are exactly what we should expect, along with equally meaningless good fortune. Such a universe would be neither evil nor good in intention. It would manifest no intentions of any kind. In a universe of blind physical forces and genetic replication, some people are going to get hurt, other people are going to get lucky, and you won't find any rhyme or reason in it, nor any justice. The universe we observe has precisely the properties we should expect if there is, at bottom, no design, no purpose, no evil and no good, nothing but blind, pitiless indifference. As that unhappy poet A.E. Housman put it:

For Nature, heartless, witless Nature
Will neither care nor know.

DNA neither knows nor cares. DNA just is. And we dance to its music.

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Extended Phenotype – But Not *Too* Extended. A Reply to Laland, Turner and Jablonka

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I am grateful to the three commentators for their thoughtful and penetrating remarks, and to the Editor for commissioning them. All three have forced me to think, re-opening neural pathways that had suffered neglect as I turned to other things in the years since *The Extended Phenotype* (henceforth *EP*) was published. Their essays raise so many interesting points, it would take another book to reply to them properly. Instead, on the basis that it is better to say a few things thoroughly than lots sketchily, I shall concentrate on what I take to be each author's central argument.

J. Scott Turner and Kevin Laland both, in their different ways, want to go further than me in extending the phenotype. Or so they see it. I am not so sure that further is the right word. Progress implies movement in a useful direction, whereas their extensions – of the organism, and into niche creation – occasionally reminded me of Stephen Leacock's knight who jumped on his horse and galloped off in all directions. I don't intend that flippantly or disrespectfully. The relevant point about the extended phenotype is that it is a *disciplined* extension. There are lots of other tempting 'extensions', which sound similar but take us off in misleading directions. I have always fought shy of misapplying the phrase to a profligate range of apparently plausible extensions.

To take a more extreme example than these commentators consider, when I am asked by lay people (as I frequently am) whether buildings count as extended phenotypes, I answer no, on the grounds that the success or failure of buildings does not affect the frequency of architects' genes in the gene pool. Extended phenotypes are worthy of the name only if they are candidate adaptations for the benefit of alleles responsible for variations in them. I might admit the theoretical possibility of generalising to other kinds of replicators such as memes (or something 'epigenetic' that Eva Jablonka might be able to explain but I wouldn't), in which case my 'no' answer might be softened. But it is enough of a problem already, getting my more hard-headed scientific colleagues to accept the extended phenotype, without arousing their active hostility by mentioning memes (which many see as simplistic) or 'epigenetic

inheritance systems' (which some might write off as obscurantist). I shall return to the important point, which I enthusiastically accept, that replicators do not have to be made of DNA in order for the logic of Darwinism to work.

Laland speaks, I suspect, for all three authors when he espouses cyclical causation. He quotes me as saying

> There are causal arrows leading from genes to body. But there is no causal arrow leading from body to genes.

Laland, who disagrees, generously wants to absolve me from responsibility for this, saying that he is quoting out of context. But I am happy to stand by it. 'Cyclical causation' leaves me cold. I must, however, make very clear that I mean causation statistically. Experimentally induced changes in bodies are never correlated with changes in genes, but changes in genes (mutations) are sometimes correlated with changes in bodies (and all evolution is the consequence). Of course most mutations occur naturally rather than experimentally, but (because corrrelation can't establish causation) I need to focus on 'experimentally induced' in order to pin down the direction of the causal arrow. It is in this statistical sense that development's arrow goes only one way. Attempts to argue for a reverse arrow recur through the history of biology, and always fail except in unimportant special-pleading senses.

Sterelny, Smith and Dickerson (1996), follow Griffiths and Gray in saying "Most acorns rot, so acorn genomes correlate better with rotting than with growth". But this is dead wrong. It misunderstands the very meaning of correlation which is, after all, a statistical technical term. Admitting that most genomes rot, the relevant question is whether *such variation as there may be* in acorn genomes correlates with *such variation as there may be* in tendency to rot. It probably does, but that isn't the point. The point is that the question of covariance is the right question to ask. Sterelny and Kitcher (1988) in their excellent paper on 'The Return of the Gene' are very clear on the matter. Think variation. Variation, variation, variation. Heritable variation; covariation between phenotype as dependent variable, and putative replicator as independent variable. This has been my *leitmotif* as I read all three commentators, and it will be my refrain throughout my reply.

Laland's main contribution to our debate is 'niche construction'. The problem I have with niche construction is that it confuses two very different impacts that organisms might have on their environments. As Sterelny (2000) put it,

> Some of these impacts are mere effects; they are byproducts of the organisms's way of life. But sometimes we should see the impact of organism on environment as the organism *engineering* its own environment: the environment is altered in ways that are adaptive for the engineering organism.

Niche construction is a suitable name only for the second of these two (and it is a special case of the extended phenotype). There is a temptation, which I regard as little short of pernicious, to invoke it for the first (byproducts) as well. Let's call the first type by the more neutral term, 'niche changing', with none of the adaptive implications of niche construction or – for that matter – of the extended phenotype.

A beaver dam, and the lake it creates, are true extended phenotypes insofar as they are adaptations for the benefit of replicators (presumably alleles but conceivably something else) that statistically have a causal influence on their construction. What crucially matters (here's the *leitmotif* again) is that *variations* in replicators have a causal link to *variations* in dams such that, over generations, replicators associated with good dams survive in the replicator pool at the expense of rival replicators associated with bad dams. Note what a stringent requirement this is. Although it is not necessary that we should already have evidence for the replicator-phenotype covariance, extended phenotype language commits us to a can only have come about through replicator-phenotype covariance. The beaver's dam is as much an adaptation as the beaver's tail. In neither case have we done the necessary research to show that it results from gene selection. In both, we have strong plausibility grounds to think it is. The same is not true – would not even be claimed by Laland and his colleagues – of most of their proposed examples of niche construction.

See how different is the 'pernicious' sense of niche construction, the byproduct that I'd prefer to sideline as 'niche changing'. Here, the dam alters the environment of the future, in some way that impinges on the life and wellbeing of beavers in general, and probably others too. Not particularly the welfare of the beavers that built the dam, not even of their children or grandchildren. The dam is good for beaverdom, and more. Beavers, frogs, fishes and marsh marigolds all benefit from a beaver-induced flooding of their niche. This is too loose and vague to count as a true extended phenotype, or as true niche construction. The deciding question is 'Who benefits?' And the reason it matters is that we have a Darwinian explanation of the dam only if dam-friendly alleles of the dam builders themselves benefit at the expense of alternative alleles.

I have no wish to downplay the importance of niche changing. It is a fair description of many important biological events, ranging from the irreversible oxygenation of Earth's early atmosphere by green bacteria and now by plants, to the greening of deserts by ecological successions of plants climaxing in dense forest communities, and including Scott Turner's *heuweltjies* (a fascinating example, of which I had been ignorant).

Most biologists would accept that the beaver dam is an evolved adaptation for the benefit of the genes of the responsible beaver. It would be a bold scientist (James Lovelock, perhaps) who would suggest that the oxygenation of the atmosphere by plants is an adaptation for the benefit of something. The oxygenation of the atmosphere is a hugely important niche change, and woe betide any creature, including any plant, that fails to adapt to it. But the presence of oxygen is nobody's adaptation (or at least, you'll have your work cut out if you want to argue that it is). It is a byproduct of plant biochemistry to which all living creatures, plants included, must adapt. Beaver dams may or may not benefit other beavers, or fishes or water beetles or pondweeds, but such diffuse and unfocused benefits cannot explain why they are there. The only benefits that can be adduced in Darwinian explanation of dams are benefits to the alleles (or other responsible replicators) of the particular beavers that build them. Otherwise, natural selection could not have shaped their evolution. Long-term consequences of niche changing are interesting and important, but they do not provide a Darwinian explanation for why animals change their niches.

Laland pays some lip service to this point when he speaks of ecological inheritance, and says that it resembles the inheritance of territory or property. Local exclusiveness is indeed a vital ingredient of true niche construction. As long as beavers have a high chance passing their lake on to their own grandchildren rather than to somebody else's grandchildren, there is at least a chance of making a workable Darwinian model of niche construction. But the rhetoric of niche construction neglects to follow the lip service, and we are left believing it to be a larger and a grander theory than it really is. Those aspects of niche construction theory that work are already included within extended phenotype theory. Those aspects that don't fit within existing extended phenotype theory don't work.

Don't work as Darwinian adaptations, that is. They can still be interesting in other ways. Earthworms are mentioned by both Laland and Turner, and Laland's splendid 'accessory kidneys' are a gift to Turner and his 'extended organism'. Earthworms radically change the environment in which they, and all other soil organisms including – significantly – rival earthworms live. Again, we certainly have niche alteration but, please, not niche construction until a lot more work has been done to establish this onerous claim.

Ecological succession is a form of niche changing – not niche construction – which follows a repeatable, regular pattern. A desert is colonised by weeds, which then change conditions sufficiently to allow the subsequent invasion by an orderly succession of plants and animals, each wave altering niches in ways that favour the next wave, culminating in a climax forest. But, important and repeatable as ecological succession is, it is not a Darwinian

adaptation on the part of prior member of the succession on behalf of later members. Rather, natural selection within the gene pools of later members of the succession favours those individuals that take advantage of the conditions inadvertently set up by earlier members. The climax forest is a consequence of colonisation by weeds decades or even centuries earlier. The forest is not an extended phenotype of the weeds' genes, nor is it helpful or illuminating to call it a niche constructed by the weeds. The same can be said of the repeatably regular pattern of development of coral reefs, in which generations of polyps build literally on the environment provided by centuries of dead predecessors, and form the foundation – literally and metaphorically – for the marine equivalent of a climax forest community.

Moving on from ecological succession to longer-term processes that look a bit like niche construction, coevolutionary arms races are the outstanding example (Dawkins and Krebs 1979). Predators impose new selection pressures on prey, which respond in evolutionary time such that future generations of prey impose changed selection pressures on future generations of predators. The coevolutionary positive feedback spirals that result are responsible for the most advanced and stunning illusions of design that the natural world has to offer. Again this is a case of animals changing future niches, and changing them in fascinating ways, but again it isn't niche construction, and no helpful purpose is served by lumping it with beaver dams or ecological succession. Understanding requires us to respect clear distinctions.

I don't denigrate niche changing as an important biological phenomenon. But it is not the same thing as true niche construction. Nothing but confusion will result from treating one as a continuation of the other. Since this seems to be a misunderstanding that is eagerly waiting to happen, niche construction is a phrase that should be abandoned forthwith.

That's all I want to say about niche construction. Now, the extended organism, which is J Scott Turner's main contribution to our debate. Turner, like Laland, is aware of the distinction between benefit to the agents responsible for a phenotype, and benefit to the world at large. But, as with Laland, his enthusiasm is in danger of misleading others into forgetting the distinction.

Turner, like Jablonka as we shall see, thinks I am too much of a genetic triumphalist. For the moment I shall leave that on one side while I focus on the wonderful examples of would-be extended organisms that Turner offers us from his own work on termites. Yes, the *Macrotermes* nest, with its underground living and brooding chambers and its overground ventilation apparatus, has many of the attributes of an organism. And yes, it is an intriguing conceit that the fungi are cultivating the termites, rather

than the other way around. Indeed, I said something pretty similar about cellulose-digesting gut microbes in *EP* (p. 208):

> Could the evolution of eusociality in the Isoptera be explained as an adaptation of the microscopic symbionts rather than of the termites themselves?

Once again, note that the extended phenotype is a *disciplined* hypothesis. Speculative as my suggestion was, it was a very specific and tightly limited speculation. Implicitly it postulated *alleles* in microorganisms (or fungi to take in Turner's hypothesis) which *vary* in their effects upon termite social behaviour (or mounds). The fact that there is no actual evidence for either speculation need not worry us at this stage. The point is to be precise about the genetic nature of the speculation. Adaptive hypotheses, however wild and speculative, must not be vaguely Panglossian but precisely limited to specified alleles (or other replicators) which *vary* and which exert a *causal* influence on *variation* in the phenotype of interest.

Let's apply these rigorous standards to the hypothesis that a termite mound is an extended organism. We shall conclude in favour, but it is important to make the case properly, in what I have called a disciplined manner. We shall take for granted the physiological, homeostatic and thermodynamic arguments put by Turner – not because they are unimportant but because he has made them so well. Instead, we concentrate on the genetics (using genes to stand for other conceivable replicators). Mound morphology is sure to be influenced by a number of genes, acting via mound embryology which, in the terms of our discussion, is another name for termite behaviour. These genes are to be found in the cells of many different organisms (using 'organism' in the conventional, non-extended sense). They include genes in the cell nuclei of numerous individual worker termites. They also might include genes in fungi, genes in gut symbionts, and genes in mitochondria or other cytoplasmic elements in the cells of termites, fungi or gut symbionts. So, we potentially have a rich pandemonium of genetic inputs to our mound phenotype, coming at it from as many as three kingdoms.

For my money, the analogy of mound with organism stands up well. The fact that we have a heterogeneously sourced genetic input to the embryology of the phenotype doesn't matter. Lots of genes affect each aspect of my bodily phenotype, including, for all I know, mitochondrial genes. My 'own' nuclear genes tug me in more or less different directions, and my phenotype is some sort of quantitative polygenic compromise. So that is not a difference that might stop the mound being an organism. What, then, is the prime characteristic of an organism? It is that, at least to a quantitatively appreciable extent, all its genes are passed on to the next generation together, in a small 'bottlenecked' propagule. The rationale for this is given in *EP*,

especially Chapter 12, 'Host phenotypes of parasite genes' and Chapter 14, 'Rediscovering the Organism', and I shall not repeat it here. Instead, let's go straight to the termite mound to see how well it holds up. Pretty well. Each new nest is founded by a single queen (or king and queen) who then, with a lot of luck, produces a colony of workers who build the mound. The founding genetic injection is, by the standards of a million-strong termite colony, an impressively small bottleneck. The same is, at least quantitatively, true of the gut symbionts with which all termites in the new nest are infected by anal licking, ultimately from the queen – the bottleneck. And the same is quantitatively true of the fungus, which is carefully transported, as a small inoculum, by the founding queen from her natal nest. All the genes that pass from a parent mound to a daughter mound do so in a small, shared package. By the bottleneck criterion, the termite mound passes muster as an extended organism, even though it is the phenotype of a teeming mass of genes sitting in many thousands of workers.

I won't miss an opportunity to emphasise (though again I shall not repeat the full argument from *EP)* that every organism (conventionally defined) is already a symbiotically cooperating union of its 'own' genes. What draws them, in a Darwinian sense, to cooperate is again 'bottlenecking': a shared statistical expectation of the future. This shared expectation follows directly from the method of reproduction, according to which all of an organism's 'own' nuclear genes, and its cytoplasmic genes for good measure, pass to the next generation in a shared propagule. To the extent that this is true of parasite genes (for example bacteria that travel inside the host's egg), to that very same extent aggressive parasitism will give way in evolutionary time to amicable and cooperative symbiosis. The parasite genes and the host genes see eye to eye on what is an optimum host phenotype. Both 'want' a host phenotype that survives and reproduces. But to the extent that parasite genes pass to their own next generation via some sideways route which is not shared with those of the host genes, to that same extent the parasite will tend to be vicious and dangerous. In such cases, the optimum phenotype from the parasite genes' point of view may well be dead – perhaps having burst in a cloud parasite spores. All our 'own' genes are mutually parasitic, but they are amicably cooperative parasites because their shared route to the future in every generation leads them to 'see eye to eye' on the optimal phenotype.

A termite mound, then, is a good extended organism. A *heuweltjie*, by my reading of Turner's description, is not. It is more like a forest or a coral reef. The genes that contribute to the putative heuweltjie phenotype don't cooperate, because they do not have a statistical expectation of sharing a propagule from the present heuweltjie to the next. Only the contingent centred around the termite genes has that shared expectation. The rest will

join the club later, from different sources, which means that, in the sense I am expounding, it is not a club. Because termite genes, with their fellow travellers, bottleneck their way from mound to mound, we can reasonably think about a form of natural selection which chooses among mounds as extended pheontypes, with adaptive consequences in an evolutionary succession of progressively improving mounds. The same will not be true of a putative natural selection of heuweltjies. Hence my statement that a heuweltjie is not a good extended organism. As in the case of Laland and his niche construction, my request to Turner is to be critical and disciplined with his notion of the extended organism. In his case, apply the bottleneck test.

At this point, I have to pick Turner up on his outrageous statement that "most would agree that the central dogma is essentially dead." It is important to do so because I suspect that many people (perhaps including present commentators who are drawn to 'cyclical causation' and similar notions) have a kind of poetic bias against Francis Crick's central dogma. This may be partly, and understandably, because of Crick's unfortunate choice of the word 'dogma', as opposed to, say, 'hypothesis' or 'theorem'. Crick's own explanation is endearing, as recounted in an interview with Horace Judson (1979). Judson asked him why he had used the word dogma and Crick replied that, because of his religious upbringing, he thought a dogma was a word for something "for which there was *no reasonable evidence.*" He had since been told by Jacques Monod that it means "something which a true believer *cannot doubt*." "You see" Crick roared with laughter as he confided in Judson, "I just didn't *know* what dogma *meant*!" Actually, the Oxford English Dictionary could be used to support either meaning.

The central dogma has been expressed in three versions, whose differences can admittedly lead to confusion: –

1. "Once information has passed into protein, *it cannot get out again*." This is Francis Crick's original wording, at the 1957 meeting of the Society for Experimental Biology and it is, as one would expect, completely clear. Note the prescience with which, long before reverse transcription was discovered, Crick in effect anticipated its irrelevance to his dogma.

> . . . the transfer of information from nucleic acid to nucleic acid, or from nucleic acid to protein may be possible, but transfer from protein to protein, or from protein to nucleic acid is impossible. Information means here the *precise* determination of sequence, either of bases in the nucleic acid or of amino acid residues in the protein (Crick 1957, quoted in Judson 1979).

In this version the central dogma has never been violated and my bet is that it never will. The genetic code, whereby nucleotide sequences are translated into amino acid sequences, is irreversible.

2. “DNA makes RNA makes protein.” This sounds pithy and clever, but it is too pithy and not clever enough. Unfortunately, it is the textbook version that students learn. But it is a summary of research findings, not a theoretical principle like Crick’s ‘dogma’. It is technically violated by reverse transcription but, as we shall see, the fact is trivial and misses the whole point of the dogma.

3. “Embryology is irreversible.” This third version is another way of saying that acquired characteristics are not inherited. It is not particularly molecular in its domain, and it owes more to Weismann than Crick, but it is interesting in being closer to 1 (theoretical principle) than to 2 (summary of known facts, now trivially violated). This version, too, has never been convincingly violated, despite many attempts.

Version 2 is disproved by reverse transcription, but this is a violation of the dogma only if we think the dogma was ever intended to apply to *both* stages of the process: transcription (DNA to RNA) as well as translation (polynucleotide to protein). But such a dogma would have been foolhardy, lacking any basis in theory, and it was explicitly excluded by Crick, with the prescience I have already praised (“the transfer of information from nucleic acid to nucleic acid”). The only ground Crick, or anybody else, ever had for confidence in his central dogma is that the information in a protein is inaccessibly buried inside the knot which the protein ties in itself – *must* tie if it is to perform its role as an enzyme. DNA is not knotted, which is why it is a lousy enzyme but very good at getting its information transcribed (into RNA, as it happens). RNA can tie itself in a kind of knot, enough to secure some sort of enzyme function (which is why some people favour it for a primitive enzyme role as well as a primitive replicator role in theories of the origin of life). But RNA doesn’t always get knotted, which is why it is good at getting its information read and translated into protein. It therefore should have surprised nobody that RNA’s information can sometimes be reverse transcribed back into DNA. Why should it not, given that it maps DNA information one to one, and it is necessarily accessible otherwise it could never be translated into protein? If Version 1, on the other hand, were ever disproved (which I doubt) it would only be by reverse translation of a structural protein like collagen or silk – un-knotted and therefore incapable of functioning as an enzyme.

Prions, contrary to widespread misunderstanding, do not violate Crick’s careful formulation of his dogma. They are replicators after a fashion, in that their alternative conformations are infectious. But the amino acid sequence of a prion is not reverse-translated into the appropriate codon sequence of a polynucleotide (look again at Crick’s prudent wording). Nor is the sequence of amino acids copied by another polypeptide chain. All that happens is that, of the alternative three dimensional conformations of a given polypeptide

sequence, one can, by its proximity, convert another existing molecule to its own shape. Nobody has ever realistically suggested that the amino acid sequence of a prion comes from any source other than DNA.

Dogma 3, the Weismannian or anti-Lamarckian pre-molecular version, is of course, the subject of old arguments, and I shall not get into all that here because it is not what Turner was talking about anyway. I'll just point out that it is a sort of whole-organism version of Crick's molecular dogma, and it is based on a similar theoretical principle. Just as amino acid sequences are inaccessibly buried in a protein, so the genetic instructions that program the development of a body are inaccessibly buried in the body itself. This is not just an empirical fact, which could be disproved at any moment by a Lamarckian finding such as a non-fraudulent case of the midwife toad. It follows from the deeper principle that embryology is not preformationistic. This is the old point about blueprints being reversible, recipes not (*EP* p. 174: 'The Poverty of Preformationism'). You can reconstruct a blueprint from a house, but not a recipe from a cake, an image that I inadvertently borrowed from my friend Patrick Bateson. Bateson's name, by the way, reminds me of my astonishment that Eva Jablonka is not the only author to sympathize with his superficially amusing but deeply misleading suggestion that a gene is a nest's way of making another nest. I shall return to this at the end.

To conclude on the central dogma, that limited part which is essentially dead (RNA cannot be reverse transcribed) should never have been born in the first place. That part of the dogma which deserved to be enunciated (and actually was enunciated by Crick) is most certainly not dead, not essentially dead, not even the tiniest bit ailing.

Let me now turn to Eva Jablonka. She, like the other two commentators, has read *EP* with flattering attention, and I am grateful for her, and their, clear disavowal of several potential misunderstandings. Genetic determinism does not follow from gene selectionism. Nor does naïve adaptationism. She is also admirably clear that "when geneticists talk about 'genes for', they are talking about genetic *differences* that make a *difference* to the phenotype." I suspect that she, like Turner, wants to have nothing to do with what he calls 'genetic triumphalism'. I agree, insofar as the 'gene' role in Darwinian models does not have to be played by DNA. If I am a triumphalist, it is a replicator triumphalist. I am happy to go along with what Sterelny (2000) has dubbed 'the extended replicator'. Indeed, I was at some pains to extend the replicator myself, in *EP*, listing several of the alternative replicators mentioned by today's three commentators: paramecium cilia, and memes, for instance. I would certainly have included prions if they had been discovered then. Jablonka is right when she says:

> Following the fortunes of heritably variable phenotypic traits in populations is common practice in evolutionary biology. We measure the genetic component of the variance in a trait in a population; models of phenotypic evolution are regularly constructed (e.g. most game theoretical models); and paleontological data, which is mostly based on morphological traits, is an accepted source of insights about evolution. Since for an entity to count as a 'fitness bearer' – a unit of adaptive evolution – it has to show (frequent) heritable variation in fitness, variant phenotypic traits are much better candidates than genes for this role.

I agree. But Jablonka should not be *surprised* that I agree. I devoted a chapter, 'Selfish Wasp or Selfish Strategy' to developing precisely the notion that a Darwinian replicator does not have to be specified as DNA, but can be a Maynard Smithian 'strategy' defined in a minimalist 'like begets like' fashion. Presumably DNA is involved in practice, but it is not a specified part of the reasoning. Jablonka's 'heritably varying phenotypic trait' is close to Williams's classic definition of the 'gene', which was the same sense in which I later called it 'selfish'.

> If there is an ultimate indivisible fragment it is, by definition, 'the gene' that is treated in the abstract definitions of population genetics (Williams 1966).

The Williams gene is only incidentally made of DNA. He later (1992) called the generalised version (what I would call a replicator) a codex, adding, "A gene is not a DNA molecule; it is the transcribable information coded by the molecule." I agree with Sterelny (and I am sure Williams would too):

> My own view is that DNA-based transmission of similarity *is* of fundamental significance. But that is not built into the structure of the theory.

Quite so. If Jablonka manages to convince the scientific community that some sort of complex feedback system of developmental cycles constitutes a true replicator, over and above its DNA content, I would be happy to embrace it. But, for the third time and at the risk of seeming pedantic, I insist on tight discipline. The criterion for recognizing a true replicator for a Darwinian model is a rigorous one. The putative replicators must vary in an open-ended way; the variants must exert phenotypic effects that influence their own survival; the variants must breed true and with high fidelity such that, when natural selection chooses one rather than its alternative, the impact persists through an indefinitely large number of generations (more precisely, survives at a high enough rate to keep pace with mutational degredation). If there is something other than DNA that meets these criteria, let us by all means include it, with enthusiasm, in our Darwinian models. But it really

must meet those criteria. Sterelny (2000) has a similar list, which he calls Hoyle Conditions because he imagines tailoring a form of life to colonise an empty world from outer space.

I am interested in the possibility that Jablonka really has a good new candidate for a true replicator, but I have to say that the use of the word 'epigenetic' makes for an unpropitious start – associated as it (no doubt unfairly) has become with obscurantism among biologists.[1] Epigenetic should be reserved for its true meaning as a historical school of embryology, hard to define except as a nebulous antonym of preformationist – which is not nebulous, is easy to define,and clearly wrong. If you want to propose an alternative replicator, extragenetic, paragenetic or quasigenetic might all be happier choices than epigenetic – not on grounds of strict etymology but because epigenetic is weighed down by inappropriate historical associations. A meme might be a quasigenetic replicator. A prion is perhaps a paragenetic replicator. Both fall down on some, but not all, of my criteria. Prions fail on the criterion of open-ended variation: the repertoire of variants for a given prion is limited to two. And memes – no, for heaven's sake don't let's get into memes now: I'll save them up to make a more worthwhile point, in a moment.

Jablonka's use of Waddington's canalization is potentially interesting (Waddington, numerous references, e.g. 1977). This isn't quite how she puts it, but canalization could play a 'self-normalizing' role. Let me explain self-normalizing, using memes in the way they are perhaps best used – by analogy. When I was a small boy at boarding school, we had to take turns in saying a goodnight prayer, kneeling up on the ends of our beds with our hands together. I can now reconstruct that the original prayer must have been that popular Evensong Collect, "Lighten our darkness, we beseech Thee O Lord, and by Thy great mercy defend us from all the perils and dangers of this night. . . ." But we only ever heard it said by each other, and none of us had a clue what most of the words meant. By the time I arrived at the school, the first line had become – and I inherited it, garbled it further, and passed it on – something like this: "Lutnar darkny sweep seech Theo Lord. . . ."

The childhood game of Chinese Whispers (American children call it Telephone) is a good model for such degradation of messages handed down over memetic 'generations'. Twenty (say) children are lined up, and a message whispered into the ear of the first. She repeats it in the ear of the second, and it passes on down the line until the twentieth child finally speaks it aloud to the assembled company – who are amused or dumbfounded at how much it has degenerated when compared with the original. As experimental memeticists we might find Chinese Whispers a useful test bed. We would compare the fidelity of various classes of message. Compare, for example, a message in a

language unknown to the children with a message they can understand. My school prayer was a sort of inadvertent running of this experiment.

When a child listens to a message and passes it on, there are two ways he can do it, one being 'normalizing' and the other not. The non-normalizing method is to imitate the sounds, phoneme by phoneme. That is approximately what the members of my dormitory were doing with 'Lighten our darkness'. The normalizing method is to treat the message, not as a set of phonemes to be imitated, but as a set of words to be looked up in a mental dictionary and then re-rendered in the child's own accents.

Cananalizing is not synonymous with digitizing but it has a similar effect. Digital codes such as DNA are protected from continuously distributed degradation, while at the same time becoming vulnerable to discrete error. Both are potential normalizing agents. Normalization is even more clearly illustrated by another meme which spread as an epidemic or craze at my father's school, and with which I re-infected the same school when I went there 26 years later. It consisted of the instructions for making an origami Chinese Junk.

> It was a remarkable feat of artificial embryology, passing through a distinctive series of intermediate stages: catamaran with two hulls, cupboard with doors, picture in a frame, and finally the junk itself, fully seaworthy or at least bathworthy, complete with deep hold, and two flat decks each surmounted by a large, square-rigged sail (Dawkins 1999).

One could imagine a version of Chinese Whispers in which what passed down the line was a hands-on demonstration of this particular skill. Unlike a drawing of a junk, which would degrade horribly down the line, the origami instructions have a good chance of making it, intact, to the twentieth child, for the reason that they are self-normalising. Here are the first five instructions for making a Chinese junk.

1. Take a square sheet of paper and fold all four corners exactly into the middle.
2. Take the reduced square so formed, and fold one side into the middle.
3. Fold the opposite side into the middle, symmetrically.
4. In the same way, take the rectangle so formed, and fold its two ends into the middle.
5. Take the small square so formed, and fold it backwards, exactly along the straight line where your last two folds met.

And so on, through 20 or 30 instructions of this kind. These instructions, though I would not wish to call them digital, are potentially of very high fidelity, just as if they were digital. This is because they all

> make reference to idealised tasks like 'fold the four corners exactly into the middle'. If the paper is not exactly square, or if a child folds ineptly so that, say, the first corner overshoots the middle and the fourth corner undershoots it, the junk that results will be inelegant. But the next child in the line will not copy the error, for she will assume that her instructor *intended* to fold all four corners into the exact centre of a perfect square. The instructions are self-normalising. The code is error correcting (Dawkins loc. cit.)

I hope the analogy to Waddingtonian canalization, and Jablonka's usage of it, is becoming clearer. A canalized embryology is resistant to change. Resistant, at least, to small, continuously distributed change, although large changes can kick Waddington's rolling ball out of the groove into a neighbouring one. Even this subtlety is well covered by the origami analogy:

> I haven't done it, but I will make the following confident prediction, assuming that we run the experiment many times on different groups of 20 children. In several of the experiments, a child somewhere along the line will forget some crucial step in the skill taught him by the previous child, and the line of phenotypes will suffer an abrupt macromutation which will presumably then be copied to the end of the line, or until another discrete mistake is made. The end result of such mutated lines will not bear any resemblance to a Chinese junk at all. But in a good number of experiments the skill will correctly pass all along the line, and the 20th junk will be no worse and no better, on average, than the first junk. If we then lay the 20 junks out in order, some will be more perfect than others, but imperfections will not be copied on down the line. If the fifth child is hamfisted and makes a clumsily asymmetrical or floppy junk, his quantitative errors will be corrected if the sixth child happens to be more dexterous (Dawkins loc. cit.).

The twenty junks will not exhibit a progressive deterioration, as they would in a game in which each child was asked to imitate a *drawing* done by the preceding child. In the light of this memetic analogy, I take it that Jablonka is proposing that canalization increases the *fidelity* of her putative replicator by resisting change, at least up to the point where the Waddingtonian 'rolling ball' is kicked into a neighbouring channel. If I am right, it is a worthwhile suggestion, which needs to be worked out more thoroughly. My hunch is that it will come to nothing, but it is interesting, nevertheless. It could have the makings of a new kind of replicator theory.

I said that I'd return to Pat Bateson and The Selfish Nest. Jablonka sympathizes with Bateson's opinion that the developmental cause-effect relationship between genes and phenotypes is circular, and that a gene can

therefore be thought of as a nest's way of making another nest. Sterelny, Smith and Dickerson (1996) go so far as to say, "Bateson was right"! No, Bateson was not right, he wasn't even close to being right, for the reasons I gave in *EP*, reasons mentioned by Jablonka, and by Sterelny et al. but, to my bafflement, not accepted by them.

> Dawkins rejected this idea on the grounds that variation is not transmitted [the *leitmotif* again, RD]. Whatever the merits of The Selfish Nest as an evolutionary hypothesis, it cannot be rejected on those grounds. First, because Dawkins here appeals to the same criterion used to exclude asexual organisms as replicators; a criterion unsatisfactory on other grounds. Second, it is not in general true. Environmentally altered patterns in cilia are inherited through fission. . . . Variation in both nesting materials and nest siting can be transmitted (Sterelny, Smith and Dickerson 1996).

My grounds for excluding asexual organisms as replicators were, in my opinion, very satisfactory. I'll reply to what Sterelny et al. went on to say:

> Dawkins appealed to fidelity to argue that asexual organisms are not replicators [*EP* p. 97]. An aphid that loses one of its legs will still give birth to six-legged offspring. . . . This criterion backfires against genetic replication. Many changes in the germline genes are not passed on. The point of the proofreading and repair mechanisms is to avoid the transmission of changes. So if genes are replicators, some changes in replicators need not be passed on; those censored by the proofreading and repair mechanisms. But then we can see the production of a six-legged aphid from its eventually five-legged forebear as a triumph of the aphid's proof-reading and correction mechanism.

Nice try. Won't do. Certainly, not all genetic changes are passed on. But no gene selectionist ever said they were. The point is that some genetic changes are passed on (otherwise there could be no evolution) but *no* environmentally acquired changes are passed on (at least not with enough high fidelity to have a chance of surviving into the indefinite future). Or, if they are passed on, they are replicators by definition and that takes care of the second part of Sterelny et al.'s objection. If environmentally altered variations in patterns of cilia are inherited (as I was happy to admit in *EP*, p. 176–177) they are replicators by definition and therefore, for present purposes, honorary genes. Aphid clones are not replicators for precisely the reason that I originally gave.

Jablonka and the school of thought dubbed 'Developmental Systems Theorists' think that the complexity of embryonic development somehow detracts from the validity of the gene's eye view of Darwinism. But we must not allow complexity to become a euphemism for muddle. Gray (1992) in 'Death of the Gene: Developmental systems strike back' says:

> . . . genetic factors do not replicate themselves nor do they physically persist across generations [*of course* they don't, that is the point of Williams's 'codex', RD]. They are replicated as part of the *reproduction* of developmental systems. Remove some part of that developmental system and genetic replication may be changed or impaired. In this sense genes are no different from any other developmental interactant.

Oh yes they are. You may be sick of hearing my *leitmotif* but we are just going to have to play it one more time as a finale. It doesn't matter how complicated the developmental support structure, nor how utterly dependent DNA may be upon it, the central question remains: which elements of the Great Batesonian Nexus of development have the property that *variations* in them are replicated, with the type of fidelity that potentially carries them through an indefinitely large number of evolutionary generations? Genes certainly meet the criterion. If anything else does, let's hear it and, if the case is well made, let's by all means elect it into membership of the replicator club. But that is a separate issue. The complexity of development itself is an obscurantist red herring. Complexity is tamed by the statistics of variation. That, for heaven's sake, is why the analysis of variance was invented, and heritability is just a special case of the analysis of variance.

This should be our response to Jablonka too, and the other commentators to the extent that they invite it. We can clearly distinguish two kinds of objection to the gene's-eye-view of selection. There is the 'genes are not the only replicators' class of objection. Let's embrace that one with open arms in principle, even though we may have to bend over backwards to accommodate some pretty specious special pleading in practice. And there is the 'Dear oh dear, development is a terribly complicated nexus, isn't it?' style of objection. Don't embrace that one. Lance the boil of obfuscatory complexity with a laser scalpel. Or mutate the metaphor, and shine a laser beam of clear statistical reasoning on what really matters, which is transgenerational covariance.

Gray repeats his error with abandon. Just one more example, in case I still have failed to get the point across.

> Lots of fun could be had with these environmentalist inversions of the gene's eye view of evolution. For example, instead of the story of the selfish gene, imagine the story of the selfish oxygen. In the evolution of the earth's atmosphere oxygen was engaged in intense competition with other atmospheric gases. With the construction of green plants oxygen developed a vehicle for its efficient replication. Chlorophyll containing organisms were thus just oxygen's way of making more oxygen (Gray, loc. cit.).

I find it disturbing that anybody could be so misled as to see this as good satire, yet I have a horrible suspicion that more than one of our three

commentators would be tempted by it. If there were alternative versions of oxygen that *varied* in their talent for exploiting plants and passed on those talents to daughter oxygens, Gray would have a point. But there aren't. Oxygen is oxygen is oxygen. There is nothing there to select.

The quality of hi-fi variation is not something cheap and easy, possessed by Bateson's nests, Gray's oxygen and just about any other unit you could think of from the world of chemistry. On the contrary, it is a precious, rare, onerous, difficult talent, possessed by genes and computer viruses and a few other things – but *genuinely* few – every one of which needs rigorous defence before biologists of critical intelligence should accept it into their Darwinian models. If it were as easy as Gray jokes, the origin of life – which means the origin of self-replicated variation – would not be the major theoretical conundrum that it is.

Hi-fi variation is not some kind of arbitrary criterion, required for scripturally dogmatic reasons stemming from the teachings of Saint George Williams. It follows from first principles, the principles that tell us why any of this matters in the first place. We are interested in evolution by natural selection. In order for anything to evolve by natural selection, there has to be variation in something that is both potentially long lasting and causally powerful, so that there emerges a difference, on the evolutionary timescale, between the state of the world if one variant survives compared with the state of the world if an alternative variant survives. If neither variant survives more than a couple of generations anyway, we are not talking evolution at all. That is why hi fi variation matters and that is why Gray's oxygen joke, Bateson's nest joke and others of their kind are not funny. There may be backwards arrows in all sorts of other senses but, in the sense that specifically matters for Darwinian evolution, the causal arrow of biological development from genotype to phenotype really is a one-way arrow.

What should I say if invited to give my own 21-year retrospective on *The Extended Phenotype?* I think Laland and Jablonka are right that the gene's-eye-view – the part of the theory that I am not responsible for inventing – really has moved to the forefront of the minds of ethologists, behavioural ecologists, sociobiologists and other evolutionary biologists in the field. This is certainly gratifying. Moreover, the study of what some people call 'ultraselfish genes' or 'selfish genetic elements' has become a major growth industry.

But the part of the theory that is wholly my own, the extended phenotype itself, unfortunately cannot yet make the same claim. It lurks somewhere near the back of some biologists' minds, but not in the lobes that plan research in the field. Twenty-one years ago, I said that nobody had done a genetic study using animal artefacts as the phenotype. I think that is still true. I would admit

to disappointment, except that it invites the obvious retort: why don't you get out there and do it yourself, then? It is a fair point. I should. Maybe I will. Idleness is a poor excuse, and preoccupation with writing books only slightly better.

Meanwhile, let me conclude with an idle pipedream. It is the beautiful Indian summer of 2010, opening day of EPI, the Extended Phenotypics Institute in one of our great university cities. After the formal unveiling by a Nobel Prizewinning scientst (Royalty wasn't considered good enough), the guests are shown wonderingly around the new building. There are three wings: the Zoological Artefact Museum (ZAM), the laboratory of Parasite Extended Genetics (PEG), and the Centre for Action at a Distance (CAD).

The artefact museum is a zoological equivalent of Oxford's Pitt Rivers, which differs from other museums of human artefacts in that its specimens are grouped functionally instead of by region of origin. Instead of sections devoted to Polynesia, Africa, Asia and pre-Columbian America, the Pitt Rivers has sections devoted to fishing nets, to wind instruments, to boats, to butchering tools, to ornamental headdresses, all gathered together with their own kind regardless of their geographic provenance. EPI's museum has all the nests together, whether made by birds, insects, mammals or spiders; all the hunting nets in another case, whether made by spiders or caddis larvae; all the sexually alluring bowers in a third, and so on. Where possible, each specimen is housed next to human equivalents, and next to functionally analogous pieces of animal anatomy: lyre bird tails next to bower bird bowers, thermoregulatory heat-exchange organs next to termite mound chimneys, and so on. A central display case shows the comparative anatomy of bird nests, each one perched on its rightful branch of a phylogenetic tree: an expanded version of the tree drawn by Winkler and Sheldon (1993) for Swallows' nests.

All around the Museum are laboratories devoted to the genetics of animal artefacts. Some would say this is, strictly speaking, the genetics of their builders, but of course the ethos of EPI acknowledges no such distinction. Artefact genetics differs from conventional genetics in that the genes whose effects bear upon any one phenotype may come from different 'organisms'. Geneticists are used to handling such summations and epistatic interactions within 'organisms' under the heading of polygenes, and our extended geneticists are well versed in the mathematical theory of polygenic inheritance (Falconer 1981). Studies in the artificial selection and genetic manipulation of silkworm cocoons enjoy a generous grant from Japan, which also supports a major project on the genetics and polymer chemistry of other silk artefacts such as spider webs and caddis larva fishing nets. The artefact museum serves as the home base for field studies of the memetics of tool making and tool use in chimpanzees, sea otters, Galapagos woodpecker finches and others.

The other two wings can be imagined by analogy with the first, and by reference to Chapters 12 and 13 of *EP*. PEG is the most prosperously endowed part of the Institute, because of the medical importance of parasite genes expressing themselves in host phenotypes. As for CAD, its generous grant from agricultural funds is prompted by the hope that artificially synthesized pheromones could revolutionise pest control. But CAD's total remit embraces nothing less than the entire field of animal communication studies and, broader yet, networks of interaction in community ecology.

In all three wings, familiar phenomena are studied from an unfamiliar perspective: different angles on a Necker cube. Everyone knows that parasites manipulate their hosts. The extended geneticists of PEG differ only in that they study variations in host behaviour and morphology as phenotypes of parasite genes. Even more than their colleagues in the artefact museum, they are never far from their well-thumbed copy of Falconer's textbook, and they are as nearly as possible indifferent to their polygenes' 'organisms' of origin. The ethologists and zoosemioticists of CAD run the risk of being mistaken for Gaian eco-mystics, as they immerse themselves in the dawn chorus and call it extended embryology. But, like their colleagues in the other two wings of EPI, they pride themselves on the disciplined rigour of their theory. The motto carved over the main door of their Institute is a one-locus mutation of St Paul: "But the greatest of these is clarity."

Note

[1] I am reminded of a satirical version of Occam's Razor, which my group of Oxford graduate students mischievously attributed to a rival establishment: "Never be satisfied with a simple explanation if a more complex one is available". And that in turn reminds me to say that Laland has missed the irony in my apparent espousal of Bateson's "Great Nexus of complex causal factors interacting in development."

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Selfish Genes and Selfish Memes[1]

Richard Dawkins

This book should be read almost as though it were science fiction. It is designed to appeal to the imagination. But it is not science fiction: it is science. Cliché or not, 'stranger than fiction' expresses exactly how I feel about the truth. We are survival machines—robot vehicles blindly programmed to preserve the selfish molecules known as genes. This is a truth which still fills me with astonishment. Though I have known it for years, I never seem to get fully used to it. One of my hopes is that I may have some success in astonishing others....

Selfish Genes

Intelligent life on a planet comes of age when it first works out the reason for its own existence. If superior creatures from space ever visit earth, the first question they will ask, in order to assess the level of our civilization, is: 'Have they discovered evolution yet?' Living organisms had existed on earth, without ever knowing why, for over three thousand million years before the truth finally dawned on one of them. His name was Charles Darwin.... We no longer have to resort to superstition when faced with the deep problems: Is there a meaning to life? What are we for? What is man?.... Today the theory of evolution is about as much open to doubt as the theory that the earth goes round the sun, but the full implications of Darwin's revolution have yet to be widely realized.... No doubt this will change in time. In any case, this book is not intended as a general advocacy of Darwinism. Instead, it will explore the consequences of the evolution theory for a particular issue. My purpose is to examine the biology of selfishness and altruism.

Apart from its academic interest, the human importance of this subject is obvious. It touches every aspect of our social lives, our loving and hating, fighting and cooperating, giving and stealing, our greed and our generosity. These are claims that could have been made for Lorenz's *On Aggression*, Ardrey's *The Social Contract*, and Eibl-Eibesfeldt's *Love and Hate*. The trouble with these books is that their authors got it totally and utterly wrong. They got it wrong because they misunderstood how evolution works. They made the erroneous assumption that the important thing in evolution is the good of the species (or the group) rather than the good of the individual (or the gene)....

Before beginning on my argument itself, I want to explain briefly what sort of an argument it is, and what sort of an argument it is not, If we were told that a man had lived a long and prosperous life in the world of Chicago gangsters, we would be entitled to make some guesses as to the sort of man he was, We might expect that he would have qualities such as toughness, a quick trigger finger, and the ability to attract loyal friends. These would not be infallible deductions, but you can make some inferences about a man's character if you know some-

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[1]Excerpts from Richard Dawkins, *The Selfish Gene*, 2d ed. (Oxford: Oxford University Press, 1989).

thing about the conditions in which he has survived and prospered. The argument of this book is that we, and all other animals, are machines created by our genes. Like successful Chicago gangsters, our genes have survived, in some cases for millions of years, in a highly competitive world. This entitles us to expect certain qualities in our genes. I shall argue that a predominant quality to be expected in a successful gene is ruthless selfishness. This gene selfishness will usually give rise to selfishness in individual behavior. However, as we shall see, there are special circumstances in which a gene can achieve its own selfish goals best by fostering a limited form of altruism at the level of individual animals. 'Special' and 'limited' are important words in the last sentence. Much as we might wish to believe otherwise, universal love and the welfare of the species as a whole are concepts that simply do not make evolutionary sense.

This brings me to the first point I want to make about what this book is not. I am not advocating a morality based on evolution. I am saying how things have evolved. I am not saying how we humans morally ought to behave. I stress this, because I know I am in danger of being misunderstood by those people, all toll numerous, who cannot distinguish a statement of belief in what is the case from an advocacy of what ought to be the case. My own feeling is that a human society based simply on the gene's law of universal ruthless selfishness would be a very nasty society in which to live. But unfortunately, however much we may deplore something, it does not stop it being true. This book is mainly intended to be interesting, but if you would extract a moral from it, read it as a warning. Be warned that if you wish, as I do, to build a society in which individuals cooperate generously and unselfishly towards a common good, you can expect little help from biological nature. Let us try to teach generosity and altruism, because we are born selfish. Let us understand what our own selfish genes are up to, because we may then at least have the chance to upset their designs, something that no other species has ever aspired to.

As a corollary to these remarks about teaching, it is a fallacy—incidentally a very common one—to suppose that genetically inherited traits are by definition fixed and unmodifiable. Our genes may instruct us to be selfish, but we are not necessarily compelled to obey them all our lives. It may just be more difficult to learn altruism than it would be if we were genetically programmed to be altruistic. Among animals, man is uniquely dominated by culture, by influences learned and handed down. Some would say that culture is so important that genes, whether selfish or not, are virtually irrelevant to the understanding of human nature. Others would disagree. It all depends where you stand in the debate over 'nature versus nurture' as determinants of human attributes. This brings me to the second thing this book is not: it is not an advocacy of one position or another in the nature/nurture controversy. Naturally I have an opinion on this, but I am not going to express it, except insofar as it is implicit in the view of culture that I shall present in the final chapter. If genes really turn out to be totally irrelevant to the determination of modern human behavior, if we really are unique among animals in this respect, it is, at the very least, still interesting to inquire about the rule to which we have so recently become the exception. And if our species is not so exceptional as we might like to think, it is even more important that we should study the rule.

The third thing this book is not is a descriptive account of the detailed behavior of man or of any other particular animal species. I shall use factual details only as illustrative examples. I shall not be saying: 'If you look at the behavior of baboons you will find it to be selfish; therefore the chances are that human behavior is selfish also'. The logic of my 'Chicago gangster' argument is quite different. It is this. Humans and baboons have evolved by natural selection. If you look at the way natural selection works, it seems to follow that anything that has evolved by natural selection should be selfish. Therefore we must expect that when we go and look at the behavior of baboons, humans, and all other living creatures, we shall find it to be selfish. If we find that our expectation is wrong, if we observe that human behavior is truly altruistic, then we shall be faced with something puzzling, something that needs explaining.

Before going any further, we need a definition. An entity, such as a baboon, is said to be altruistic if it behaves in such a way as to increase another such entity's welfare at the expense of its own. Selfish behavior has exactly the opposite effect. 'Welfare' is defined as 'chances of survival', even if the effect on actual life and death prospects is so small as to *seem* negligible. One of the surprising consequences of the modern version of the Darwinian theory is that apparently trivial tiny influences on survival probability can have a major impact on evolution. This is because of the enormous time available for such influences to make themselves felt.

It is important to realize that the above definitions of altruism and selfishness are *behavioural*, not subjective. I am not concerned here with the psychology of motives. I am not going to argue about whether people who behave altruistically are 'really' doing it for secret or subconscious selfish motives. Maybe they are and maybe they aren't, and maybe we can never know, but in any case that is not what this book is about. My definition is concerned only with whether the *effect* of an act is to lower or raise the survival prospects of the presumed altruist and the survival prospects of the presumed beneficiary....

In the beginning was simplicity. It is difficult enough explaining how even a simple universe began. I take it as agreed that it would be even harder to explain the sudden springing up, fully armed, of complex order—life, or a being capable of creating life. Darwin's theory of evolution by natural selection is satisfying because it shows us a way in which simplicity could change into complexity, how unordered atoms could group themselves into ever more complex patterns until they ended up manufacturing people. Darwin provides a solution, the only feasible one so far suggested, to the deep problem of our existence. I will try to explain the great theory in a more general way than is customary, beginning with the time before evolution itself began.

Darwin s 'survival of the fittest' is really a special case of a more general law of *survival of the stable*. The universe is populated by stable things. A stable thing is a collection of atoms which is permanent enough or common enough to deserve a name. It may be a unique collection of atoms, such as the Matterhorn, which lasts long enough to be worth naming. Or it may be a *class* of entities, such as rain drops, which come into existence at a sufficiently high rate to deserve a collective name, even if any one of them is short-lived. The things which we see around us, and which we think of as needing explanation—rocks, galaxies, ocean waves—are all, to a greater or lesser extent, stable patterns of atoms. Soap bubbles tend to be spherical because this is a stable configuration for thin films filled with gas. In a spacecraft, water is also stable in spherical globules, but on earth, where there is gravity, the stable surface for standing water is flat and horizontal. Salt crystals tend to be cubes because this is a stable way of packing sodium and chloride ions together. In the sun the simplest atoms of all, hydrogen atoms, are fusing to form helium atoms, because in the conditions which prevail there the helium configuration is more stable. Other even more complex atoms are being formed in stars all over the universe, and were formed in the 'big bang' which, according to the prevailing theory, initiated the universe. This is originally where the elements on our world came from.

Sometimes when atoms meet they link up together in chemical reaction to form molecules, which may be more or less stable. Such molecules can be very large. A crystal such as a diamond can be regarded as a single molecule, a proverbially stable one in this case, but also a very simple one since its internal atomic structure is endlessly repeated. In modern living organisms there are other large molecules which are highly complex, and their complexity shows itself on several levels. The hemoglobin of our blood is a typical protein molecule. It is built up from chains of smaller molecules, amino acids, each containing a few dozen atoms arranged in a precise pattern. In the hemoglobin molecule there are 574 amino acid molecules. These are arranged in four chains, which twist around each other to form a globular three-dimensional structure of bewildering complexity. A model of a hemoglobin molecule looks rather like a dense thornbush. But unlike a real thornbush it is not a haphazard approximate pattern but a definite invariant structure, identically repeated, with not a twig nor a twist out of place, over six thousand million million million times in an average human body. The precise thornbush shape of a protein molecule such as hemoglobin is 'stable in the sense that two chains consisting of the same sequences of amino acids will tend, like two springs, to come to rest in exactly the same three-dimensional coiled pattern. Hemoglobin thornbushes are springing into their 'preferred' shape in your body at a rate of about four hundred million million per second, and others are being destroyed at the same rate.

Hemoglobin is a modern molecule, used to illustrate the principle that atoms tend to fall into stable patterns. The point that is relevant here is that, before the coming of life on earth, some rudimentary evolution of molecules could have occurred by ordinary processes of physics and chemistry. There is no need to think of design or purpose or directedness. If a group of atoms in the presence of energy falls into a stable pattern it will tend to stay that way. The earliest form of natural selection was simply a selection of stable forms and a rejection of unstable ones. There is no mystery about this. It had to happen by definition.

From this, of course, it does not follow that you can explain the existence of entities as complex as man by exactly the same principles on their own. It is no good taking the right number of atoms and shaking them together with some external energy till they happen to fall into the right pattern, and out drops Adam! You may make a molecule consisting of a few dozen atoms like that, but a man consists of over a thousand million million million million atoms. To try to make a man, you would have to work at your biochemical cocktail-shaker for a period so long that the entire age of the universe would seem like an eye-blink, and even then you would not succeed. This is where Darwin's theory, in its most general form, comes to the rescue. Darwin's theory takes over from where the story of the slow building up of molecules leaves off.

The account of the origin of life which I shall give is necessarily speculative; by definition, nobody was around to see what happened. There are a number of rival theories, but they all have certain features in common. The simplified account I shall give is probably not too far from the truth.

We do not know what chemical raw materials were abundant on earth before the coming of life, but among the plausible possibilities are water, carbon dioxide, methane, and ammonia: all simple compounds known to be present on at least some of the other planets in our solar system. Chemists have tried to imitate the chemical conditions of the young earth. They have put these simple substances in a flask and supplied a source of energy such as ultraviolet light or electric sparks— artificial simulation of primordial lightning. After a few weeks of this, something interesting is usually found inside the flask: a weak brown soup containing a large number of molecules more complex than the ones originally put in. In particular, amino acids have been found—the building blocks of proteins, one of the two great classes of biological molecules. Before these experiments were done, naturally occurring amino acids would have been thought of as diagnostic of the presence of life. If they had been detected on, say, Mars, life on that planet would have seemed a near certainty. Now, however, their existence need imply only the presence of a few simple gases in the atmosphere and some volcanoes, sunlight, or thundery weather. More recently, laboratory simulations of the chemical conditions of earth before the coming of life have yielded organic substances called purines and pyrimidines. These are building blocks of the genetic molecule, DNA itself.

Processes analogous to these must have given rise to the ‘primeval soup’ which biologists and chemists believe constituted the seas some three to four thousand million years ago. The organic substances became locally concentrated, perhaps in drying scum round the shores, or in tiny suspended droplets. Under the further influence of energy such as ultraviolet light from the sun, they combined into larger molecules. Nowadays large organic molecules would not last long enough to be noticed: they would be quickly absorbed and broken down by bacteria or other living creatures. But bacteria and the rest of us are late-comers, and in those days large organic molecules could drift unmolested through the thickening broth.

At some point a particularly remarkable molecule was formed by accident. We will call it the *Replicator*. It may not necessarily have been the biggest or the most complex molecule around, but it had the extraordinary property of being able to create copies of itself. This may seem a very unlikely sort of accident to happen. So it was. It was exceedingly improbable. In the lifetime of a man, things which are that improbable can be treated for practical purposes as impossible. That is why you will never win a big prize on the football pools. But in our human estimates of what is probable and what is not, we are not used to dealing in hundreds of millions of years. If you filled in pools coupons every week for a hundred million years you would very likely win several jackpots.

Actually a molecule which makes copies of itself is not as difficult to imagine as it seems at first, and it only had to arise once. Think of the replicator as a mold or template. Imagine it as a large molecule consisting of a complex chain of various sorts of building block molecules. The small building blocks were abundantly available in the soup surrounding the replicator. Now suppose that each building block has an affinity for its own kind. Then whenever a building block from out in the soup lands up next to a part of the replicator for which it has an affinity, it will tend to stick there. The building blocks which attach themselves in this way will automatically be arranged in a sequence which mimics that of the replicator itself. It is easy then to think of them joining up to form a stable chain just as in the formation of the original replicator. This process could continue as a progressive stacking up, layer upon layer. This is how crystals are formed. On the other hand, the two chains might split apart, in which case we have two replicators, each of which can go on to make further copies.

A more complex possibility is that each building block has affinity not for its own kind, but reciprocally for one particular other kind. Then the replicator would act as a template not for an identical copy, but for a kind of ‘negative’, which would in its turn remake an exact copy of the original positive. For our purposes it does not matter whether the original replication process was positive–negative or positive–positive, though it is worth remarking that the modern equivalents of the first replicator, the DNA molecules, use positive–negative replication. What does matter is that suddenly a new kind of ‘stability’ came into the world. Previously it is probable that no particular kind of complex molecule was very abundant in the soup, because each was dependent on building blocks happening to fall by luck into a particular stable configuration. As soon as the replicator was born it must have spread its copies rapidly throughout the seas, until the smaller building block molecules became a scarce resource, and other larger molecules were formed more and more rarely.

So we seem to arrive at a large population of identical replicas. But now we must mention an important property of any copying process: it is not perfect. Mistakes will happen. I hope there are no misprints in this book, but if you look carefully you may find one or two. They will probably not seriously distort the meaning of the sentences, because they will be ‘first-generation’ errors. But imagine the days before printing, when books such as the Gospels were copied by hand. All scribes, however careful, are bound to make a few errors, and some are not above a little willful ‘improvement’. If they all copied from a single master original, meaning would not be greatly perverted. But let copies be made from other copies, which in their turn were made from other copies, and errors will start to become cumulative and serious. We tend to regard erratic copying as a bad thing, and in the case of human documents it is hard to think of examples where errors can be described as improvements. I suppose the scholars of the Septuagint could at least be said to have started something big when they mistranslated the Hebrew word for ‘young woman’ into the Greek word for ‘virgin’, coming up with the prophecy: ‘Behold a virgin shall conceive and bear a son...’ Anyway, as we shall see, erratic copying in biological replicators can in a real sense give rise to improvement, and it was essential for the progressive evolution of life that some errors were made. We do not know how accurately the original replicator molecules made their copies. Their modern descendants, the DNA molecules, are astonishingly faithful compared with the most high-fidelity human copying process, but even they occasionally make mistakes, and it is ultimately these mistakes which make evolution possible. Probably the original replicators were far more erratic, but in any case we may be sure that mistakes were made, and these mistakes were cumulative.

As mis-copyings were made and propagated, the primeval soup became filled by a population not of identical replicas, but of several varieties of replicating molecules, all ‘descended’ from the same ancestor. Would some varieties have been more numerous than others? Almost certainly yes. Some varieties would have been inherently more stable than others. Certain molecules, once formed, would be less likely than others to break up again. These types would become relatively numerous in the soup, not only as a direct logical consequence of their 'longevity', but also because they would have a long time available for making copies of themselves. Replicators of high longevity would therefore tend to become more numerous and, other things being equal, there would have been an 'evolutionary trend' toward greater longevity in the population of molecules.

But other things were probably not equal, and another property of a replicator variety which must have had even more importance in spreading it through the population was speed of replication, or 'fecundity'. If replicator molecules of type *A* make copies of themselves on average once a week while those of type *B* make copies of themselves once an hour, it is not difficult to see that pretty soon type *A* molecules are going to be far outnumbered, even if they 'live' much longer than *B* molecules. There would therefore probably have been an 'evolutionary trend' towards higher 'fecundity' of molecules in the soup. A third characteristic of replicator molecules which would have been positively selected is accuracy of replication. If molecules of type *X* and type *Y* last the same length of time and replicate at the same rate, but *X* makes a mistake on average every tenth replication while *Y* makes a mistake only every hundredth replication, *Y* will obviously become more numerous. The *X* contingent in the population loses not only the errant 'children' themselves, but also all their descendants, actual or potential.

If you already know something about evolution, you may find something slightly paradoxical about the last point. Can we reconcile the idea that copying errors are an essential prerequisite for evolution to occur, with the statement that natural selection favors high copying-fidelity? The answer is that although evolution may seem, in some vague sense, a 'good thing', especially since we are the product of it, nothing actually 'wants' to evolve. Evolution is something that happens, willy-nilly, in spite of all the efforts of the replicators (and nowadays of the genes) to prevent it happening. Jacques Monod made this point very well in his Herbert Spencer lecture, after wryly remarking: 'Another curious aspect of the theory of evolution is that everybody thinks he understands it!'

To return to the primeval soup, it must have become populated by stable varieties of molecule; stable in that either the individual molecules lasted a long time, or they replicated rapidly, or they replicated accurately. Evolutionary trends toward these three kinds of stability took place in the following sense: If you had sampled the soup at two different times, the later sample would have contained a higher proportion of varieties with high longevity/fecundity/copying-fidelity. This is essentially what a biologist means by evolution when he is speaking of living creatures, and the mechanism is the same—natural selection.

Should we then call the original replicator molecules 'living'? Who cares? I might say to you 'Darwin was the greatest man who has ever lived', and you might say, 'No, Newton was', but I hope we would not prolong the argument. The point is that no conclusion of substance would be affected whichever way our argument was resolved. The facts of the lives and achievements of Newton and Darwin remain totally unchanged whether we label them 'great' or not. Similarly, the story of the replicator molecules probably happened something like the way I am telling it, regardless of whether we choose to call them 'living'. Human suffering has been caused because too many of us cannot grasp that words are only tools for our use, and that the mere presence in the dictionary of a word like 'living' does not mean it necessarily has to refer to something definite in the real world. Whether we call the early replicators living or not, they were the ancestors of life; they were our founding fathers.

The next important link in the argument, one which Darwin himself laid stress on (although he was talking about animals and plants, not molecules) is *competition*. The primeval soup was not capable of supporting an infinite number of replicator molecules. For one thing, the earth's size is finite, but other limiting factors must also have been important. In our picture of the replicator acting as a template or mold, we supposed it to be bathed in a soup rich in the small building block molecules necessary to make copies. But when the replicators became numerous, building blocks must have been used up at such a rate that they became a scarce and precious resource. Different varieties or strains of replicator must have competed for them. We have considered the factors which would have increased the numbers of favored kinds of replicator. We can now see that less-favored varieties must actually have become less numerous because of competition, and ultimately many of their lines must have gone extinct. There was a struggle for existence among replicator varieties. They did not know they were struggling, or worry about it; the struggle was conducted without any hard feelings, indeed without feelings of any kind. But they were struggling, in the sense that any mis-copying which resulted in a new higher level of stability, or a new way of reducing the stability of rivals, was automatically preserved and multiplied. The process of improvement was cumulative. Ways of increasing stability and of decreasing rivals' stability became more elaborate and more efficient. Some of them may even have 'discovered' how to break up molecules of rival varieties chemically, and to use the building blocks so released for making their own copies. These proto-carnivores simultaneously obtained food and removed competing rivals. Other replicators perhaps discovered how to protect themselves, either chemically or by building a physical wall of protein around themselves. This may have been how the first living cells appeared. Replicators began not merely to exist, but to construct for themselves containers, vehicles for their continued existence. The replicators which survived were the ones which built *survival machines* for themselves to live in. The first survival machines probably consisted of nothing more than a protective coat. But making a living got steadily harder as new rivals arose with better and more effective survival machines. Survival machines got bigger and more elaborate, and the process was cumulative and progressive.

Was there to be any end to the gradual improvement in the techniques and artifices used by the replicators to ensure their own continuance in the world? There would be plenty of time for improvement. What weird engines of self-preservation would the millennia bring forth? Four thousand million years on, what was to be the fate of the ancient replicators? They did not die out, for they are past masters of the survival arts. But do not look for them floating loose in the sea; they gave up that cavalier freedom long ago. Now they swarm in huge colonies, safe inside gigantic lumbering robots, sealed off from the outside world, communicating with it by tortuous indirect routes, manipulating it by remote control. They are in you and in me; they created us, body and mind; and their preservation is the ultimate rationale for our existence. They have come a long way, those replicators. Now they go by the name of genes, and we are their survival machines....

.... Once upon a time, natural selection consisted of the differential survival of replicators floating free in the primeval soup. Now natural selection favors replicators which are good at building survival machines, genes which are skilled in the art of controlling embryonic development. In this, the replicators are no more conscious or purposeful than they ever were. The same old processes of automatic selection between rival molecules by reason of their longevity, fecundity, and copying-fidelity, still go on as blindly and as inevitably as they did in the far-off days. Genes have no foresight. They do not plan ahead. Genes just *are*, some genes more so than others, and that is all there is to it. But the qualities which determine a gene's longevity and fecundity are not so simple as they were. Not by a long way.

In recent years—the last six hundred million or so—the replicators have achieved notable triumphs of survival-machine technology such as the muscle, the heart, and the eye (evolved several times independently). Before that, they radically altered fundamental features of their way of life as replicators, which must be understood if we are to proceed with the argument.

The first thing to grasp about a modern replicator is that it is highly gregarious. A survival machine is a vehicle containing not just one gene but many thousands. The manufacture of a body is a cooperative venture of such intricacy that it is almost impossible to disentangle the contribution of one gene from that of another. A given gene will have many different effects on quite different parts of the body. A given part of the body will be influenced by many genes, and the effect of any one gene depends on interaction with many others. Some genes act as master genes controlling the operation of a cluster of other genes. In terms of the analogy, any given page of the plans makes reference to many different parts of the building; and each page makes sense only in terms of cross-references to numerous other pages.

This intricate interdependence of genes may make you wonder why we use the word 'gene' at all. Why not use a collective noun like 'gene complex'? The answer is that for many purposes that is indeed quite a good idea. But if we look at things in another way, it does make sense too to think of the gene complex as being divided up into discrete replicators or genes. This arises because of the phenomenon of sex. Sexual reproduction has the effect of mixing and shuffling genes. This means that any one individual body is just a temporary vehicle for a short-lived combination of genes. The *combination* of genes that is any one individual may be short-lived, but the genes themselves are potentially very long-lived. Their paths constantly cross and recross down the generations. One gene may be regarded as a unit which survives through a large number of successive individual bodies....

Natural selection in its most general form means the differential survival of entities. Some entities live and others die but, in order for this selective death to have any impact on the world, an additional condition must be met. Each entity must exist in the form of lots of copies, and at least some of the entities must be *potentially* capable of surviving—in the form of copies—for a significant period of evolutionary time. Small genetic units have these properties; individuals, groups, and species do not. It was the great achievement of Gregor Mendel to show that hereditary units can be treated in practice as indivisible and independent particles. Nowadays we know that this is a little too simple. Even a cistron is occasionally divisible and any two genes on the same chromosome are not wholly independent. What I have done is to define a gene as a unit which, to a high degree, *approaches* the ideal of indivisible particulateness. A gene is not indivisible, but it is seldom divided. It is either definitely present or definitely absent in the body of any given individual. A gene travels intact from grandparent to grandchild, passing straight through the intermediate generation without being merged with other genes. If genes continually blended with each other, natural selection as we now understand it would be impossible. Incidentally, this was proved in Darwin's lifetime, and it caused Darwin great worry since in those days it was assumed that heredity was a blending process. Mendel's discovery had already been published, and it could have rescued Darwin, but alas he never knew about it: nobody seems to have read it until years after Darwin and Mendel had both died. Mendel perhaps did not realize the significance of his findings, otherwise he might have written to Darwin.

Another aspect of the particulateness of the gene is that it does not grow senile; it is no more likely to die when it is a million years old than when it is only a hundred. It leaps from body to body down the generations, manipulating body after body in its own way and for its own ends, abandoning a succession of mortal bodies before they sink in senility and death.

The genes are the immortals, or rather, they are defined as genetic entities which come close to deserving the title. We, the individual survival machines in the world, can expect to live a few more decades. But the genes in the world have an expectation of life which must be measured not in decades but in thousands and millions of years....

Survival machines began as passive receptacles for the genes, providing little more than walls to protect them from the chemical warfare of their rivals and the ravages of accidental molecular bombardment. In the early days they 'fed' on organic molecules freely available in the soup. This easy life came to an end when the organic food in the soup, which had been slowly built up under the energetic influence of centuries of sunlight, was all used up. A major branch of survival machines, now called plants, started to use sunlight directly themselves to build up complex molecules from simple ones, reenacting at much higher speed the synthetic processes of the original soup. Another branch, now known as animals, 'discovered' how to exploit the chemical labors of the plants, either by eating them, or by eating other animals. Both main branches of survival machines evolved more and more ingenious tricks to increase their efficiency in their various ways of life, and new ways of life were continually being opened up. Subbranches and sub-subbranches evolved, each one excelling in a particular specialized way of making a living: in the sea, on the ground, in the air, underground, up trees, inside other living bodies. This subbranching has given rise to the immense diversity of animals and plants which so impresses us today.

Both animals and plants evolved into many-celled bodies, complete copies of all the genes being distributed to every cell. We do not know when, why, or how many times independently, this happened. Some people use the metaphor of a colony, describing a body as a colony of cells. I prefer to think of the body as a colony of genes, and of the cell as a convenient working unit for the chemical industries of the genes.

Colonies of genes they may be but, in their behavior, bodies have undeniably acquired an individuality of their own. An animal moves as a coordinated whole, as a unit. Subjectively I feel like a unit, not a colony. This is to be expected. Selection has favored genes which cooperate with others. In the fierce competition for scarce resources, in the relentless struggle to eat other survival machines, and to avoid being eaten, there must have been a premium on central coordination rather than anarchy within the communal body. Nowadays the intricate mutual coevolution of genes has proceeded to such an extent that the communal nature of an individual survival machine is virtually unrecognizable. Indeed many biologists do not recognize it, and will disagree with me....

One of the most striking properties of survival-machine behavior is its apparent purposiveness. By this I do not just mean that it seems to be well calculated to help the animal's genes to survive, although of course it is. I am talking about a closer analogy to human purposeful behavior. When we watch an animal 'searching' for food, or for a mate, or for a lost child, we can hardly help imputing to it some of the subjective feelings we ourselves experience when we search. These may include 'desire' for some object, a 'mental picture' of the desired object, an 'aim' or 'end in view'. Each one of us knows, from the evidence of his own introspection, that, at least in one modern survival machine, this purposiveness has evolved the property we call 'consciousness'. I am not philosopher enough to discuss what this means, but fortunately it does not matter for our present purposes because it is easy to talk about machines which behave *as if* motivated by a purpose, and to leave open the question whether they actually are conscious. These machines are basically very simple, and the principles of unconscious purposive behavior are among the commonplaces of engineering science. The classic example is the Watt steam governor.

The fundamental principle involved is called negative feedback, of which there are various different forms. In general what happens is this. The 'purpose machine', the machine or thing that behaves as if it had a conscious purpose, is equipped with some kind of measuring device which measures the discrepancy between the current state of things and the 'desired' state. It is built in such a way that the larger this discrepancy is, the harder the machine works. In this way the machine will automatically tend to reduce the discrepancy—this is why it is called *negative* feedback—and it may actually come to rest if the 'desired' state is reached. The Watt governor consists of a pair of balls which are whirled round by a steam engine. Each ball is on the end of a hinged arm. The faster the balls fly round, the more does centrifugal force push the arms toward a horizontal position, this tendency being resisted by gravity. The arms are connected to the steam valve feeding the engine, in such a way that the steam tends to be shut off when the arms approach the horizontal position. So, if the engine goes too fast, some of its steam will be shut off, and it will tend to slow down. If it slows down too much, more steam will automatically be fed to it by the valve, and it will speed up again. Such purpose machines often oscillate due to overshooting and time-lags, and it is part of the engineer's art to build in supplementary devices to reduce the oscillations.

The 'desired' state of the Watt governor is a particular speed of rotation. Obviously it does not consciously desire it. The 'goal' of a machine is simply defined as that state to which it tends to return. Modern purpose machines use extensions of basic principles like negative feedback to achieve much more complex 'lifelike' behavior. Guided missiles, for example, appear to search actively for their target, and when they have it in range they seem to pursue it, taking account of its evasive twists and turns, and sometimes even 'predicting' or 'anticipating' them. The details of how this is done are not worth going into. They involve negative feedback of various kinds, 'feed-forward', and other principles well understood by engineers and now known to be extensively involved in the working of living bodies. Nothing remotely approaching consciousness needs to be postulated, even though a layman, watching its apparently deliberate and purposeful behavior, finds it hard to believe that the missile is not under the direct control of a human pilot.

It is a common misconception that because a machine such as a guided missile was originally designed and built by conscious man, then it must be truly under the immediate control of conscious man. Another variant of this fallacy is 'computers do not really play chess, because they can only do what a human operator tells them'. It is important that we understand why this is fallacious, because it affects our understanding of the sense in which genes can be said to 'control' behavior. Computer chess is quite a good example for making the point, so I will discuss it briefly.

Computers do not yet play chess as well as human grand masters, but they have reached the standard of a good amateur. More strictly, one should say *programs* have reached the standard of a good amateur, for a chess-playing program is not fussy which physical computer it uses to act out its skills. Now, what is the role of the human programmer? First, he is definitely not manipulating the computer from moment to moment, like a puppeteer pulling strings. That would be just cheating. He writes the program, puts it in the computer, and then the computer is on its own: there is no further human intervention, except for the opponent typing in his moves. Does the programmer perhaps anticipate all possible chess positions and provide the computer with a long list of good moves, one for each possible contingency? Most certainly not, because the number of possible positions in chess is so great that the world would come to an end before the list had been completed. For the same reason, the computer cannot possibly be programmed to try out 'in its head' all possible moves, and all possible follow-ups, until it finds a winning strategy. There are more possible games of chess than there are atoms in the galaxy. So much for the trivial nonsolutions to the problem of programming a computer to play chess. It is in fact an exceedingly difficult problem, and it is hardly surprising that the best programs have still not achieved grand master status.

The programmer's actual role is rather more like that of a father teaching his son to play chess. He tells the computer the basic moves of the game, not separately for every possible starting position, but in terms of more economically expressed rules. He does not literally say in plain English 'bishops move in a diagonal', but he does say something mathematically equivalent, such as, though more briefly: 'New coordinates of bishop are obtained from old coordinates, by adding the same constant, though not necessarily with the same sign, to both old *x* coordinate and old *y* coordinate'. Then he might program in some 'advice', written in the same sort of mathematical or logical language, but amounting in human terms to hints such as 'don't leave your king unguarded', or useful tricks such as 'forking' with the knight. The details are intriguing, but they would take us too far afield. The important point is this: When it is actually playing, the computer is on its own and can expect no help from its master. All the programmer can do is to set the computer up *beforehand* in the best way possible, with a proper balance between lists of specific knowledge and hints about strategies and techniques.

The genes too control the behavior of their survival machines, not directly with their fingers on puppet strings, but indirectly like the computer programmer. All they can do is to set it up beforehand; then the survival machine is on its own, and the genes can only sit passively inside. Why are they so passive? Why don't they grab the reins and take charge from moment to moment? The answer is that they cannot because of time-lag problems. This is best shown by another analogy, taken from science fiction. *A for Andromeda* by Fred Hoyle and John Elliot is an exciting story, and, like all good science fiction, it has some interesting scientific points lying behind it. Strangely, the book seems to lack explicit mention of the most important of these underlying points. It is left to the reader's imagination. I hope the authors will not mind if I spell it out here.

There is a civilization two hundred light years away, in the constellation of Andromeda.[2] They want to spread their culture to distant worlds. How best to do it? Direct travel is out of the question. The speed of light imposes a theoretical upper limit to the rate at which you can get from one place to another in the universe, and mechanical considerations impose a much lower limit in practice. Besides, there may not be all that many worlds worth going to, and how do you know which direction to go in? Radio is a better way of communicating with the rest of the universe, since, if you have enough power to broadcast your signals in all directions rather than beam them in one direction, you can reach a very large number of worlds (the number increasing as the square of the distance the signal travels). Radio waves travel at the speed of light, which means the signal takes two hundred years to reach Earth from Andromeda. The trouble with this sort of distance is that you can never hold a conversation. Even if you discount the fact that each successive message from Earth would be transmitted by people separated from each other by twelve generations or so, it would be just plain wasteful to attempt to converse over such distances.

This problem will soon arise in earnest for us: it takes about four minutes for radio waves to travel between Earth and Mars. There can be no doubt that spacemen will have to get out of the habit of conversing in short alternating sentences, and will have to use long soliloquies or monologues, more like letters than conversations. As another example, Roger Payne has pointed out that the acoustics of the sea have certain peculiar properties, which mean that the exceedingly loud 'song' of the humpback whale could theoretically be heard all the way round the world, provided the whales swim at a certain depth. It is not known whether they actually do communicate with each other over very great distances, but if they do they must be in much the same predicament as an astronaut on Mars. The speed of sound in water is such that it would take nearly two hours for the song to travel across the Atlantic Ocean and for a reply to return. I suggest this as an explanation for the fact that the whales deliver a continuous soliloquy, without repeating themselves, for a full eight minutes. They then go back to the beginning of the song and repeat it all over again, many times over, each complete cycle lasting about eight minutes.

[2][Not to be confused with the Andromeda galaxy, which is two million light years away.]

The Andromedans of the story did the same thing. Since there was no point in waiting for a reply, they assembled everything they wanted to say into one huge unbroken message, and then they broadcast it out into space, over and over again, with a cycle time of several months. Their message was very different from that of the whales, however. It consisted of coded instructions for the building and programming of a giant computer. Of course the instructions were in no human language, but almost any code can be broken by a skilled cryptographer, especially if the designers of the code intended it to be easily broken. Picked up by the Jodrell Bank radio telescope, the message was eventually decoded, the computer built, and the program run. The results were nearly disastrous for mankind, for the intentions of the Andromedans were not universally altruistic, and the computer was well on the way to dictatorship over the world before the hero eventually finished it off with an axe.

From our point of view, the interesting question is in what sense the Andromedans could be said to be manipulating events on Earth. They had no direct control over what the computer did from moment to moment; indeed they had no possible way of even knowing the computer had been built, since the information would have taken two hundred years to get back to them. The decisions and actions of the computer were entirely its own. It could not even refer back to its masters for general policy instructions. All its instructions had to be built-in in advance, because of the inviolable two-hundred-year barrier. In principle, it must have been programmed very much like a chess-playing computer, but with greater flexibility and capacity for absorbing local information. This was because the program had to be designed to work not just on earth, but on any world possessing an advanced technology, any of a set of worlds whose detailed conditions the Andromedans had no way of knowing.

Just as the Andromedans had to have a computer on earth to take day-to-day decisions for them, our genes have to build a brain. But the genes are not only the Andromedans who sent the coded instructions; they are also the instructions themselves. The reason why they cannot manipulate our puppet strings directly is the same: time-lags. Genes work by controlling protein synthesis. This is a powerful way of manipulating the world, but it is slow. It takes months of patiently pulling protein strings to build an embryo. The whole point about behavior, on the other hand, is that it is fast. It works on a time scale not of months but of seconds and fractions of seconds. Something happens in the world, an owl flashes overhead, a rustle in the long grass betrays prey, and in milliseconds nervous systems crackle into action, muscles leap, and someone's life is saved—or lost. Genes don't have reaction times like that. Like the Andromedans, the genes can do only their best *in advance* by building a fast executive computer for themselves, and programming it in advance with rules and 'advice' to cope with as many eventualities as they can 'anticipate'. But life, like the game of chess, offers too many different possible eventualities for all of them to be anticipated. Like the chess programmer, the genes have to 'instruct' their survival machines not in specifics, but in the general strategies and tricks of the living trade.

As J. Z. Young has pointed out, the genes have to perform a task analogous to prediction. When an embryo survival machine is being built, the dangers and problems of its life lie in the future. Who can say what carnivores crouch waiting for it behind what bushes, or what fleet-footed prey will dart and zigzag across its path? No human prophet, nor any gene. But some general predictions can be made. Polar bear genes can safely predict that the future of their unborn survival machine is going to be a cold one. They do not think of it as a prophecy, they do not think at all: they just build in a thick coat of hair, because that is what they have always done before in previous bodies, and that is why they still exist in the gene pool. They also predict that the. ground is going to be snowy, and their prediction takes the form of making the coat of hair white and therefore camouflaged. If the climate of the Arctic changed so rapidly that the baby bear found itself born into a tropical desert, the predictions of the genes would be wrong, and they would pay the penalty. The young bear would die, and they inside it....

One of the most interesting methods of predicting the future is simulation. If a general wishes to know whether a particular military plan will be better than alternatives, he has a problem in prediction. There are unknown quantities in the weather, in the morale of his own troops, and in the possible countermeasures of the enemy. One way of discovering whether it is a good plan is to try it and see, but it is undesirable to use this test for all the tentative plans dreamed up, if only because the supply of young men prepared to die ‘for their country’ is exhaustible and the supply of possible plans is very large. It is better to try the various plans out in dummy runs rather than in deadly earnest. This may take the form of full-scale exercises with ‘Northland’ fighting ‘Southland’ using blank ammunition, but even this is expensive in time and materials. Less wastefully, war games may be played, with tin soldiers and little toy tanks being shuffled around a large map.

Recently, computers have taken over large parts of the simulation function, not only in military strategy, but in all fields where prediction of the future is necessary, fields like economics, ecology, sociology, and many others. The technique works like this. A model of some aspect of the world is set up in the computer. This does not mean that if you unscrewed the lid you would see a little miniature dummy inside with the same shape as the object simulated. In the chess-playing computer there is no ‘mental picture’ inside the memory banks recognizable as a chess board with knights and pawns sitting on it. The chess board and its current position would be represented by lists of electronically coded numbers. To us a map is a miniature scale model of a part of the world, compressed into two dimensions. In a computer, a map would more probably be represented as a list of towns and other spots, each with two numbers—its latitude and longitude. But it does not matter how the computer actually holds its model of the world in its head, provided that it holds it in a form in which it can operate on it, manipulate it, do experiments with it, and report back to the human operators in terms which they can understand. Through the technique of simulation, model battles can be won or lost, simulated airliners fly or crash, economic policies lead to prosperity or to ruin. In each case the whole process goes on inside the computer in a tiny fraction of the time it would take in real life. Of course there are good models of the world and bad ones, and even the good ones are only approximations. No amount of simulation can predict exactly what will happen in reality, but a good simulation is enormously preferable to blind trial and error. Simulation could be called vicarious trial and error, a term unfortunately preempted long ago by rat psychologists.

If simulation is such a good idea, we might expect that survival machines would have discovered it first. After all, they invented many of the other techniques of human engineering long before we came on the scene: the focusing lens and the parabolic reflector, frequency analysis of sound waves, servo-control, sonar, buffer storage of incoming information, and countless others with long names, whose details don't matter. What about simulation? Well, when you yourself have a difficult decision to make involving unknown quantities in the future, you do go in for a form of simulation. You *imagine* what would happen if you did each of the alternatives open to you. You set up a model in your head, not of everything in the world, but of the restricted set of entities which you think may be relevant. You may see them vividly in your mind's eye, or you may see and manipulate stylized abstractions of them. In either case it is unlikely that somewhere laid out in your brain is an actual spatial model of the events you are imagining. But, just as in the computer, the details of how your brain represents its model of the world are less important than the fact that it is able to use it to predict possible events. Survival machines which can simulate the future are one jump ahead of survival machines who can only learn on the basis of overt trial and error. The trouble with overt trial is that it takes time and energy. The trouble with overt error is that it is often fatal. Simulation is both safer and faster.

The evolution of the capacity to simulate seems to have culminated in subjective consciousness. Why this should have happened is, to me, the most profound mystery facing modern biology. There is no reason to suppose that electronic computers are conscious when they simulate, although we have to admit that in the future they may become so. Perhaps consciousness arises when the brain's simulation of the world becomes so complete that it must include a model of itself. Obviously the limbs and body of a survival machine must constitute an important part of its simulated world; presumably for the same kind of reason, the simulation itself could be regarded as part of the world to be simulated. Another word for this might indeed be 'self-awareness', but I don't find this a fully satisfying explanation of the evolution of consciousness, and this is only partly because it involves an infinite regress—if there is a model of the model, why not a model of the model of the model...?

Whatever the philosophical problems raised by consciousness, for the purpose of this story it can be thought of as the culmination of an evolutionary trend towards the emancipation of survival machines as executive decision-takers from their ultimate masters, the genes. Not only are brains in charge of the day-to-day running of survival-machine affairs, they have also acquired the ability to predict the future and act accordingly. They even have the power to rebel against the dictates of the genes, for instance in refusing to have as many children as they are able to. But in this respect man is a very special case, as we shall see.

What has all this to do with altruism and selfishness? I am trying to build up the idea that animal behavior, altruistic or selfish, is under the control of genes in only an indirect, but still very powerful, sense. By dictating the way survival machines and their nervous systems are built, genes exert ultimate power over behavior. But the moment-to-moment decisions about what to do next are taken by the nervous system. Genes are the primary policy-makers; brains are the executives. But as brains became more highly developed, they took over more and more of the actual policy decisions, using tricks like learning and simulation in doing so. The logical conclusion to this trend, not yet reached in any species, would be for the genes to give the survival machine a single overall policy instruction: do whatever you think best to keep us alive....

You Scratch My Back, I'll Ride on Yours

.... Several species of ants in the new world, and, quite independently, termites in Africa, cultivate 'fungus gardens'. The best known are the so-called parasol ants of South America. These are immensely successful. Single colonies with more than two million individuals have been found. Their nests consist of huge spreading underground complexes of passages and galleries going down to a depth of ten feet or more, made by the excavation of as much as 40 tons of soil. The underground chambers contain the fungus gardens. The ants deliberately sow fungus of a particular species in special compost beds which they prepare by chewing leaves into fragments. Instead of foraging directly for their own food, the workers forage for leaves to make compost. The 'appetite' of a colony of parasol ants for leaves is gargantuan. This makes them a major economic pest, but the leaves are not food for themselves but food for their fungi. The ants eventually harvest and eat the fungi and feed them to their brood. The fungi are more efficient at breaking down leaf material than the ants' own stomachs would be, which is how the ants benefit by the arrangement. It is possible that the fungi benefit too, even though they are cropped: the ants propagate them more efficiently than their own spore dispersal mechanism might achieve. Furthermore, the ants 'weed' the fungus gardens, keeping them clear of alien species of fungi. By removing competition, this may benefit the ants' own domestic fungi. A kind of relationship of mutual altruism could be said to exist between ants and fungi. It is remarkable that a very similar system of fungus-farming has evolved independently, among the quite unrelated termites.

Ants have their own domestic animals as well as their crop plants. Aphids—greenfly and similar bugs—are highly specialized for sucking the juice out of plants. They pump the sap up out of the plants' veins more efficiently than they subsequently digest it. The result is that they excrete a liquid which has had only some of its nutritious value extracted. Droplets of sugar-rich 'honeydew' pass out of the back end at a great rate, in some cases more than the insect's own body-weight every hour. The honeydew normally rains down on to the ground—it may well have been the providential food known as 'manna' in the Old Testament. But ants of several species intercept it as soon as it leaves the bug. The ants 'milk' the aphids by stroking their hindquarters with their feelers and legs. Aphids respond to this, in some cases apparently holding back their droplets until an ant strokes them, and even withdrawing a droplet if an ant is not ready to accept it. It has been suggested that some aphids have evolved a backside which looks and feels like an ant's face, the better to attract ants. What the aphids have to gain from the relationship is apparently protection from their natural enemies. Like our own dairy cattle they lead a sheltered life, and aphid species which are much cultivated by ants have lost their normal defensive mechanisms. In some cases ants care for the aphid eggs inside their own underground nests, feed the young aphids, and finally, when they are grown, gently carry them up to the protected grazing grounds.

A relationship of mutual benefit between members of different species is called mutualism or symbiosis. Members of different species often have much to offer each other because they can bring different 'skills' to the partnership. This kind of fundamental asymmetry can lead to evolutionarily stable strategies of mutual cooperation. Aphids have the right sort of mouthparts for pumping up plant sap, but such sucking mouthparts are no good for self-defence. Ants are no good at sucking sap from plants, but they are good at fighting. Ant genes for cultivating and protecting aphids have been favoured in ant gene-pools. Aphid genes for cooperating with the ants have been favoured in aphid gene-pools.

Symbiotic relationships of mutual benefit are common among animals and plants. A lichen appears superficially to be an individual plant like any other. But it is really an intimate symbiotic union between a fungus and a green alga. Neither partner could live without the other. If their union had become just a bit more intimate we would no longer have been able to tell that a lichen was a double organism at all. Perhaps then there are other double or multiple organisms which we have not recognized as such. Perhaps even we ourselves?

Within each one of our cells there are numerous tiny bodies called mitochondria. The mitochondria are chemical factories, responsible for providing most of the energy we need. If we lost our mitochondria we would be dead within seconds. Recently it has been plausibly argued that mitochondria are, in origin, symbiotic bacteria who joined forces with our type of cell very early in evolution. Similar suggestions have been made for other small bodies within our cells. This is one of those revolutionary ideas which it takes time to get used to, but it is an idea whose time has come. I speculate that we shall come to accept the more radical idea that each one of our genes is a symbiotic unit. We are gigantic colonies of symbiotic genes. One cannot really speak of 'evidence' for this idea, but, as I tried to suggest in earlier chapters, it is really inherent in the very way we think about how genes work in sexual species. The other side of this coin is that viruses may be genes who have broken loose from 'colonies' such as ourselves. Viruses consist of pure DNA (or a related self-replicating molecule) surrounded by a protein jacket. They are all parasitic. The suggestion is that they have evolved from 'rebel' genes who escaped, and now travel from body to body directly through the air, rather than via the more conventional vehicles—sperms and eggs. If this is true, we might just as well regard ourselves as colonies of viruses! Some of them cooperate symbiotically, and travel from body to body in sperms and eggs. These are the conventional 'genes'. Others live parasitically, and travel by whatever means they can. If the parasitic DNA travels in sperms and eggs, it perhaps forms the 'paradoxical' surplus of DNA which I mentioned in Chapter 3. If it travels through the air, or by other direct means, it is called 'virus' in the usual sense.

But these are speculations for the future. At present we are concerned with symbiosis at the higher level of relationships between many-celled organisms, rather than within them. The word symbiosis is conventionally used for associations between members of different species. But, now that we have eschewed the 'good of the species' view of evolution, there seems no logical reason to distinguish associations between members of different species as things apart from associations between members of the same species. In general, associations of mutual benefit will evolve if each partner can get more out than he puts in. This is true whether we are speaking of members of the same hyena pack, or of widely distinct creatures such as ants and aphids, or bees and flowers. In practice it may be difficult to distinguish cases of genuine two-way mutual benefit from cases of one-sided exploitation.

The evolution of associations of mutual benefit is theoretically easy to imagine if the favours are given and received simultaneously, as in the case of the partners who make up a lichen. But problems arise if there is a delay between the giving of a favour and its repayment. This is because the first recipient of a favour may be tempted to cheat and refuse to pay it back when his turn comes. The resolution of this problem is interesting and is worth discussing in detail. I can do this best in terms of a hypothetical example.

Suppose a species of bird is parasitized by a particularly nasty kind of tick which carries a dangerous disease. It is very important that these ticks should be removed as soon as possible. Normally an individual bird can pull off its own ticks when preening itself. There is one place, however—the top of the head—which it cannot reach with its own bill. The solution to the problem quickly occurs to any human. An individual may not be able to reach his own head, but nothing is easier than for a friend to do it for him. Later, when the friend is parasitized himself, the good deed can be paid back. Mutual grooming is in fact very common in both birds and mammals.

This makes immediate intuitive sense. Anybody with conscious foresight can see that it is sensible to enter into mutual back-scratching arrangements. But we have learnt to beware of what seems intuitively sensible. The gene has no foresight. Can the theory of selfish genes account for mutual back-scratching, or 'reciprocal altruism', where there is a delay between good deed and repayment? Williams briefly discussed the problem in his 1966 book, to which I have already referred. He concluded, as had Darwin, that delayed reciprocal altruism can evolve in species which are capable of recognizing and remembering each other as individuals. Trivers, in 1971, took the matter further. When he wrote, he did not have available to him Maynard Smith's concept of the evolutionarily stable strategy. If he had, my guess is that he would have made use of it, for it provides a natural way to express his ideas. His reference to the 'Prisoner's Dilemma'—a favourite puzzle in game theory—shows that he was already thinking along the same lines.

Suppose *B* has a parasite on the top of his head. *A* pulls it off him. Later, the time comes when *A* has a parasite on his head. He naturally seeks out *B* in order that *B* may pay back his good deed. *B* simply turns up his nose and walks off. *B* is a cheat, an individual who accepts the benefit of other individuals' altruism, but who does not pay it back, or who pays it back insufficiently. Cheats do better than indiscriminate altruists because they gain the benefits without paying the costs. To be sure, the cost of grooming another individual's head seems small compared with the benefit of having a dangerous parasite removed, but it is not negligible. Some valuable energy and time has to be spent.

Let the population consist of individuals who adopt one of two strategies. As in Maynard Smith's analyses, we are not talking about conscious strategies, but about unconscious behaviour programs laid down by genes. Call the two strategies Sucker and Cheat. Suckers groom anybody who needs it, indiscriminately cheats accept altruism from suckers, but they never groom anybody else, not even somebody who has previously groomed them. As in the case of the hawks and doves, we arbitrarily assign pay-off points. It does not matter what the exact values are, so long as the benefit of being groomed exceeds the cost of grooming. If the incidence of parasites is high, any individual sucker in a population of suckers can reckon on being groomed about as often as he grooms. The average pay-off for a sucker among suckers is therefore positive. They all do quite nicely in fact, and the word sucker seems inappropriate. But now suppose a cheat arises in the population. Being the only cheat, he can count on being groomed by everybody else, but he pays nothing in return. His average pay-off is better than the average for a sucker. Cheat genes will therefore start to spread through the population. Sucker genes will soon be driven to extinction. This is because, no matter what the ratio in the population, cheats will always do better than suckers. For instance, consider the case when the population consists of 50 per cent suckers and 50 per cent cheats. The average pay-off for both suckers and cheats will be less than that for any individual in a population of 100 per cent suckers. But still, cheats will be doing better than suckers because they are getting all the benefits—such as they are—and paying nothing back. When the proportion of cheats reaches 90 per cent, the average pay-off for all individuals will be very low: many of both types may by now be dying of the infection carried by the ticks. But still the cheats will be doing better than the suckers. Even if the whole population declines toward extinction, there will never be any time when suckers do better than cheats. Therefore, as long as we consider only these two strategies, nothing can stop the extinction of the suckers and, very probably, the extinction of the whole population too.

But now, suppose there is a third strategy called Grudger. Grudgers groom strangers and individuals who have previously groomed them. However, if any individual cheats them, they remember the incident and bear a grudge: they refuse to groom that individual in the future. In a population of grudgers and suckers it is impossible to tell which is which. Both types behave altruistically towards everybody else, and both earn an equal and high average pay-off. In a population consisting largely of cheats, a single grudger would not be very successful. He would expend a great deal of energy grooming most of the individuals he met—for it would take time for him to build up grudges against all of them. On the other hand, nobody would groom him in return. If grudgers are rare in comparison with cheats, the grudger gene will go extinct. Once the grudgers manage to build up in numbers so that they reach a critical proportion, however, their chance of meeting each other becomes sufficiently great to off-set their wasted effort in grooming cheats. When this critical proportion is reached they will start to average a higher pay-off than cheats, and the cheats will be driven at an accelerating rate towards extinction. When the cheats are nearly extinct their rate of decline will become slower, and they may survive as a minority for quite a long time. This is because for any one rare cheat there is only a small chance of his encountering the same grudger twice: therefore the proportion of individuals in the population who bear a grudge against any given cheat will be small.

I have told the story of these strategies as though it were intuitively obvious what would happen. In fact it is not all that obvious, and I did take the precaution of simulating it on a computer to check that intuition was right. Grudger does indeed turn out to be an evolutionarily stable strategy against sucker and cheat, in the sense that, in a population consisting largely of grudgers, neither cheat nor sucker will invade. Cheat is also an ESS, however, because a population consisting largely of cheats will not be invaded by either grudger or sucker. A population could sit at either of these two ESSs. In the long term it might flip from one to the other. Depending on the exact values of the pay-offs—the assumptions in the simulation were of course completely arbitrary—one or other of the two stable states will have a larger ‘zone of attraction’ and will be more likely to be attained. Note incidentally that, although a population of cheats may be more likely to go extinct than a population of grudgers, this in no way affects its status as an ESS. If a population arrives at an ESS which drives it extinct, then it goes extinct, and that is just too bad.

It is quite entertaining to watch a computer simulation which starts with a strong majority of suckers, a minority of grudgers which is just about the critical frequency, and about the same-sized minority of cheats. The first thing that happens is a dramatic crash in the population of suckers as the cheats ruthlessly exploit them. The cheats enjoy a soaring population explosion, reaching their peak just as the last sucker perishes. But the cheats still have the grudgers to reckon with. During the precipitous decline of the suckers, the grudgers have been slowly decreasing in numbers, taking a battering from the prospering cheats, but just managing to hold their own. After the last sucker has gone and the cheats can no longer get away with selfish exploitation so easily, the grudgers slowly begin to increase at the cheats' expense. Steadily their population rise gathers momentum. It accelerates steeply, the cheat population crashes to near extinction, then levels out as they enjoy the privileges of rarity and the comparative freedom from grudges which this brings. However, slowly and inexorably the cheats are driven out of existence, and the grudgers are left in sole possession. Paradoxically, the presence of the suckers actually endangered the grudgers early on in the story because they were responsible for the temporary prosperity of the cheats.

By the way, my hypothetical example about the dangers of not being groomed is quite plausible. Mice kept in isolation tend to develop unpleasant sores on those parts of their heads which they cannot reach. In one study, mice kept in groups did not suffer in this way, because they licked each others' heads. It would be interesting to test the theory of reciprocal altruism experimentally and it seems that mice might be suitable subjects for the work.

Trivers discusses the remarkable symbiosis of the cleaner-fish. Some fifty species, including small fish and shrimps, are known to make their living by picking parasites off the surface of larger fish of other species. The large fish obviously benefit from being cleaned, and the cleaners get a good supply of food. The relationship is symbiotic. In many cases the large fish open their mouths and allow cleaners right inside to pick their teeth, and then to swim out through the gills which they also clean. One might expect that a large fish would craftily wait until he had been thoroughly cleaned, and then gobble up the cleaner. Yet instead he usually lets the cleaner swim off unmolested. This is a considerable feat of apparent altruism because in many cases the cleaner is of the same size as the large fish's normal prey.

Cleaner-fish have special stripy patterns and special dancing displays which label them as cleaners. Large fish tend to refrain from eating small fish who have the right kind of stripes, and who approach them with the right kind of dance. Instead they go into a trance-like state and allow the cleaner free access to their exterior and interior. Selfish genes being what they are, it is not surprising that ruthless, exploiting cheats have cashed in. There are species of small fish that look just like cleaners and dance in the same kind of way in order to secure safe conduct into the vicinity of large fish. When the large fish has gone into its expectant trance the cheat, instead of pulling off a parasite, bites a chunk out of the large fish's fin and beats a hasty retreat. But in spite of the cheats, the relationship between fish cleaners and their clients is mainly amicable and stable.

The profession of cleaner plays an important part in the daily life of the coral reef community. Each cleaner has his own territory, and large fish have been seen queuing up for attention like customers at a barber's shop. It is probably this site-tenacity which makes possible the evolution of delayed reciprocal-altruism in this case. The benefit to a large fish of being able to return repeatedly to the same 'barber's shop', rather than continually searching for a new one, must outweigh the cost of refraining from eating the cleaner. Since cleaners are small, this is not hard to believe. The presence of cheating cleaner-mimics probably indirectly endangers the bona-fide cleaners by setting up a minor pressure on large fish to eat stripy dancers. Site-tenacity on the part of genuine cleaners enables customers to find them and to avoid cheats.

A long memory and a capacity for individual recognition are well developed in man. We might therefore expect reciprocal altruism to have played an important part in human evolution. Trivers goes so far as to suggest that many of our psychological characteristics—envy, guilt, gratitude, sympathy, etc.—have been shaped by natural selection for improved ability to cheat, to detect cheats, and to avoid being thought to be a cheat. Of particular interest are 'subtle cheats' who appear to be reciprocating, but who consistently pay back slightly less than they receive. It is even possible that man's swollen brain, and his predisposition to reason mathematically, evolved as a mechanism of ever more devious cheating, and ever more penetrating detection of cheating in others. Money is a formal token of delayed reciprocal altruism.

There is no end to the fascinating speculation which the idea of reciprocal altruism engenders when we apply it to our own species. Tempting as it is, I am no better at such speculation than the next man, and I leave the reader to entertain himself....

Selfish Memes

.... The laws of physics are supposed to be true all over the accessible universe. Are there any principles of biology which are likely to have similar universal validity? When astronauts voyage to distant planets and look for life, they can expect to find creatures too strange and unearthly for us to imagine. But is there anything which must be true of all life, wherever it is found, and whatever the basis of its chemistry? If forms of life exist whose chemistry is based on silicon rather than carbon, or ammonia rather than water, if creatures are discovered which boil to death at –100 degrees centigrade, if a form of life is found which is not based on chemistry at all but on electronic reverberating circuits, will there still be any general principle which is true of all life? Obviously I do not know but, if I had to bet, I would put my money on one fundamental principle. This is the law that all life evolves by the differential survival of replicating entities. The gene, the DNA molecule, happens to be the replicating entity which prevails on our own planet. There may be others. If there are, provided certain other conditions are met, they will almost inevitably tend to become the basis for an evolutionary process.

But do we have to go to distant worlds to find other kinds of replicator and other, consequent, kinds of evolution? I think that a new kind of replicator has recently emerged on this very planet. It is staring us in the face. It is still in its infancy, still drifting clumsily about in its primeval soup, but already it is achieving evolutionary change at a rate which leaves the old gene panting far behind.

The new soup is the soup of human culture. We need a name for the new replicator, a noun which conveys the idea of a unit of cultural transmission, or a unit of *imitation*. 'Mimeme' comes from a suitable Greek root, but I want a monosyllable that sounds a bit like 'gene'. I hope my classicist friends will forgive me if I abbreviate mimeme to meme. If it is any consolation, it could alternatively be thought of as being related to memory, or to the French word *même*. It should be pronounced to rhyme with 'cream'.

Examples of memes are tunes, ideas, catch-phrases, clothes fashions, ways of making pots or of building arches. Just as genes propagate themselves in the gene pool by leaping from body to body via sperms or eggs, so memes propagate themselves in the meme pool by leaping from brain to brain via a process which, in the broad sense, can be called imitation. If a scientist hears, or reads about, a good idea, he passes it on to his colleagues and students. He mentions it in his articles and his lectures. If the idea catches on, it can be said to propagate itself, spreading from brain to brain. As my colleague N. K. Humphrey neatly summed up an earlier draft of this chapter: '... memes should be regarded as living structures, not just metaphorically but technically. When you plant a fertile meme in my mind, you literally parasitize my brain, turning it into a vehicle for the meme's propagation in just the way that a virus may parasitize the genetic mechanism of a host cell. And this isn't just a way of talking—the meme for, say, "belief in life after death" is actually realized physically, millions of times over, as a structure in the nervous systems of individual men the world over.'....

I conjecture that co-adapted meme-complexes evolve in the same kind of way as co-adapted gene-complexes. Selection favours memes which exploit their cultural environment to their own advantage. This cultural environment consists of other memes which are also being selected. The meme pool therefore comes to have the attributes of an evolutionarily stable set, which new memes find it hard to invade.

I have been a bit negative about memes, but they have their cheerful side as well. When we die there are two things we can leave behind us: genes and memes. We were built as gene machines, created to pass on our genes. But that aspect of us will be forgotten in three generations. Your child, even your grandchild, may bear a resemblance to you, perhaps in facial features, in a talent for music, in the colour of her hair. But as each generation passes, the contribution of your genes is halved. It does not take long to reach negligible proportions. Our genes may be immortal but the *collection* of genes which is any one of us is bound to crumble away. Elizabeth II is a direct descendant of William the Conqueror. Yet it is quite probable that she bears not a single one of the old king's genes. We should not seek immortality in reproduction.

But if you contribute to the world's culture, if you have a good idea, compose a tune, invent a spark plug, write a poem, it may live on, intact, long after your genes have dissolved in the common pool. Socrates may or may not have a gene or two alive in the world today, as G. C. Williams has remarked, but who cares? The meme-complexes of Socrates, Leonardo, Copernicus, and Marconi are still going strong....

Trial by Jury - Richard Dawkins

Trial by Jury by Richard Dawkins. Published as “Three herring gull chicks . . . the reason juries don’t work” in The Observer (London), Sunday November 16, 1997.

Trial by jury must be one of the most conspicuously bad good ideas anyone ever had. Its devisers can hardly be blamed. They lived before the principles of statistical sampling and experimental design had been worked out. They weren’t scientists. Let me explain using an analogy. And if, at the end, somebody objects to my argument on the grounds that humans aren’t herring gulls, I’ll have failed to get my point across. Adult herring gulls have a bright yellow bill with a conspicuous red spot near the tip. Their babies peck at the red spot, which induces the parents to regurgitate food for them. Niko Tinbergen, Nobel-Prizewinning zoologist and my old maestro at Oxford, offered naive young chicks a range of cardboard dummy gull heads varying in bill and spot colour, and shape. For each colour, shape or combination, Tinbergen measured the preferences of the baby chicks by counting their pecks in a standard time. The idea was to discover whether naive gull chicks are born with a built-in preference for long yellow things with red spots. If so, this would suggest that genes equip the young birds with detailed prior knowledge of the world in which they are about to hatch – a world in which food comes out of adult herring gull beaks.

Never mind the reason for the research, and never mind the conclusions. Consider, instead, the methods you must use, and the pitfalls you must avoid, if you want to get a correct result in any such experiment. These turn out to be general principles which apply to human juries as strongly as to gull chicks.

First, you obviously must test more than one chick. It could be that some chicks are red-biased, others blue-biased, with no tendency for herring gull chicks in general to share the same favourite colour. So, by picking out a single chick, you are measuring nothing more than individual bias. It is no answer to this objection that our chick may have given hundreds more pecks to one colour than to the other. A chick might begin by choosing any old colour at random, but once he has chosen he gets ‘locked on’ to that colour and hammers away at it, giving the other colours no chance. The essential problem here is that successive pecks, however numerous, are not ‘independent data’.

So, we must test more than one chick. How many? Is two enough? No, nor is three, and now we must start to think statistically. To make it simple, suppose that in a particular experiment we are comparing only red spots versus blue spots, both on a yellow background, and always presented simultaneously. If we test just two chicks separately, suppose the first chick chooses red. It had a 50% chance of doing so, at random. Now the second chick also happens to choose red. Again, the odds were 50% that it would do so at random, even if it were colourblind. There’s a 50% chance that two randomly choosing chicks will agree (half of the four possibilities: red red, red blue, blue red, blue blue). Three chicks aren’t enough either. If you write down all the possibilities, you’ll find that there’s a 25% chance of a unanimous verdict, by luck alone. Twenty five percent, as the odds of reaching a conclusion for the wrong reason, is unacceptably large.

How about twelve good chicks and true? Now you’re talking. If twelve chicks are independently offered a choice between two alternatives, the odds that they will all reach the same verdict by chance alone are satisfyingly low, only one in 1024.

But now suppose that, instead of testing our twelve chicks independently, we test them as a group. We take a maelstrom of twelve cheeping chicks and lower into their midst a red spotted dummy and a blue spotted dummy, each fitted with an electrical device for automatically tallying pecks. And suppose that the collective of chicks registers 532 pecks at red and zero at blue. Does this massive disparity show that herring gull chicks, in general, prefer red? Absolutely not. The pecks are not independent data. Chicks could have a strong tendency to imitate one another (as well as imitate themselves in lock-on effects). If one chick just happened to peck at red first, others might copy him and the whole company of chicks join in a frenzy of imitative pecking. As a matter of fact this is precisely what domestic chicken chicks do, and gull chicks are very likely the same. Even if not, the principle remains that the data are not independent and the experiment is therefore invalid. The twelve chicks are strictly equivalent to a single chick, and their summed pecks amount to only a single independent result.

Turning to courts of law, why are twelve jurors preferred to a single judge? Not because they are wiser, more knowledgeable or more practised in the arts of reasoning. Certainly not, and with a vengeance. Think of the astronomical damages awarded by juries in footling libel cases. Think how juries bring out the worst in histrionic, gallery-playing lawyers. Twelve jurors are preferred to one judge only because they are more numerous. Letting a single judge decide a verdict would be like letting a single chick speak for the whole herring gull species. Twelve heads are better than one, because they represent twelve assessments of the evidence. But for this argument to be valid, the twelve assessments really have to be independent. And of course they are not. Twelve men and women locked in a jury room are like our clutch of twelve gull chicks. Whether they actually imitate each other like chicks, they might. That is enough to invalidate the principle by which a jury might be preferred over a single judge.

In practice, as is well documented and as I remember from the three juries that it has been my misfortune to serve on, juries are massively swayed by one or two vocal individuals. There is also strong pressure to conform to a unanimous verdict, which further undermines the principle of independent data. Increasing the number of jurors doesn't help, or not much (and not at all in strict principle). What you have to increase is the number of independent verdict-reaching units.

Oddly enough, the bizarre American system of televising trials opens up a real possibility of improving the jury system. By the end of trials such as those of Louise Woodward or O. J. Simpson, literally thousands of people around the country have attended to the evidence as assiduously as the official jury. A mass phone-in might produce a fairer verdict than a jury. But unfortunately journalistic discussion, radio talk-shows, and ordinary gossip would violate the Principle of Independent Data and we'd be back where we started. The broadcasting of trials, in any case, has horrible consequences. In the wake of Louise Woodward's trial, the Internet seethes with ill-spelled and ungrammatical viciousness, the cheque-book journalists are queuing up, and the unfortunate Judge Zobel has had to change his telephone number and employ a bodyguard. So, how can we improve the system? Should twelve jurors be locked in twelve isolation chambers and their opinions separately polled so that they constitute genuinely independent data? If it is objected that some would be too stupid or inarticulate to reach a verdict on their own, we are left wondering why such individuals are allowed on a jury at all.

Perhaps there is something to be said for the collective wisdom that emerges when a group of twelve people thrash out a topic together, round a table. But this still leaves the principle of independent data unsatisfied. Should all cases be tried by two separate juries? Or three? Or twelve? Too expensive, at least if each jury has twelve members. Two juries of six members, or three juries of four members, would probably be an improvement over the present system. But isn't there some way of testing the relative merits of such alternative options, or of comparing the merits of trial by jury versus trial by judge?

Yes, there is. I'll call it the Two Verdicts Concordance Test. It is based on the principle that, if a decision is valid, two independent shots at making it should yield the same result. Just for purposes of the test, we run to the expense of having two juries, listening to the same case and forbidden to talk to members of the other jury. At the end, we lock the two juries in two separate jury rooms and see if they reach the same verdict. If they don't, nothing can be proved beyond reasonable doubt, and this would cast reasonable doubt on the jury system itself. To make the experimental comparison with Trial by Judge, we need two experienced judges to listen to the same case, and require them too to reach their separate verdicts without talking to each other. Whichever system, Trial by Jury or Trial by Judge, yields the higher score of agreements over a number of trials is the better system and might even be accredited for future use with some confidence. Would you bet on two independent juries reaching the same verdict in the Louise Woodward case? Could you imagine even one other jury reaching the same verdict in the O. J. Simpson case? Two judges, on the other hand, seem to me rather likely to score well on the concordance test. And should I be charged with a serious crime here's how I want to be tried. If I know myself to be guilty, I'll go with the loose cannon of a jury, the more ignorant, prejudiced and capricious the better. But if I am innocent, and the ideal of multiple independent decision-takers is unavailable, please give me a judge. Preferably Judge Hiller Zobel.

The Improbability of God

by Richard Dawkins

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Much of what people do is done in the name of God. Irishmen blow each other up in his name. Arabs blow themselves up in his name. Imams and ayatollahs oppress women in his name. Celibate popes and priests mess up people's sex lives in his name. Jewish *shohets* cut live animals' throats in his name. The achievements of religion in past history - bloody crusades, torturing inquisitions, mass-murdering conquistadors, culture-destroying missionaries, legally enforced resistance to each new piece of scientific truth until the last possible moment - are even more impressive. And what has it all been in aid of? I believe it is becoming increasingly clear that the answer is absolutely nothing at all. There is no reason for believing that any sort of gods exist and quite good reason for believing that they do not exist and never have. It has all been a gigantic waste of time and a waste of life. It would be a joke of cosmic proportions if it weren't so tragic.

Why do people believe in God? For most people the answer is still some version of the ancient Argument from Design. We look about us at the beauty and intricacy of the world - at the aerodynamic sweep of a swallow's wing, at the delicacy of flowers and of the butterflies that fertilize them, through a microscope at the teeming life in every drop of pond water, through a telescope at the crown of a giant redwood tree. We reflect on the electronic complexity and optical perfection of our own eyes that do the looking. If we have any imagination, these things drive us to a sense of awe and reverence. Moreover, we cannot fail to be struck by the obvious resemblance of living organs to the carefully planned designs of human engineers. The argument was most famously expressed in the watchmaker analogy of the eighteenth-century priest William Paley. Even if you didn't know what a watch was, the obviously designed character of its cogs and springs and of how they mesh together for a purpose would force you to conclude "that the watch must have had a maker: that there must have existed, at some time, and at some place or other, an artificer or artificers, who formed it for the purpose which we find it actually to answer; who comprehended its construction, and designed its use." If this is true of a comparatively simple watch, how much the more so is it true of the eye, ear, kidney, elbow joint, brain? These beautiful, complex, intricate, and obviously purpose-built structures must have had their own designer, their own watchmaker - God.

So ran Paley's argument, and it is an argument that nearly all thoughtful and sensitive people discover for themselves at some stage in their childhood. Throughout most of history it must have seemed utterly convincing, self-evidently true. And yet, as the result of one of the most astonishing intellectual revolutions in history, we now know that it is wrong, or at least superfluous. We now know that the order and apparent purposefulness of the living world has come about through an entirely different process, a process that works without the need for any designer and one that is a consequence of basically very simple laws of physics. This is the process of evolution by natural selection, discovered by Charles Darwin and, independently, by Alfred Russel Wallace.

What do all objects that look as if they must have had a designer have in common? The answer is statistical improbability. If we find a transparent pebble washed into the shape of a crude lens by the sea, we do not conclude that it must have been designed by an optician: the unaided laws of physics are capable of achieving this result; it is not too improbable to have just "happened." But if we find an elaborate compound lens, carefully corrected against spherical and chromatic aberration, coated against glare, and with "Carl Zeiss" engraved on the rim, we know that it could not have just happened by chance. If you take all the atoms of such a compound lens and throw them together at random under the jostling influence of the ordinary laws of physics in nature, it is *theoretically* possible that, by sheer luck, the atoms would just happen to fall into the pattern of a Zeiss compound lens, and even that the atoms round the rim should happen to fall in such a way that the name Carl Zeiss is etched out. But the number of other ways in which the atoms could, with equal likelihood, have fallen, is so hugely, vastly, immeasurably greater that we can completely discount the chance hypothesis. Chance is out of the question as an explanation.

This is not a circular argument, by the way. It might seem to be circular because, it could be said, *any* particular arrangement of atoms is, with hindsight, very improbable. As has been said before, when a ball lands on a particular blade of grass on the golf course, it would be foolish to exclaim: "Out of all the billions of blades of grass that it *could* have fallen on, the ball actually fell on this one. How amazingly, miraculously improbable!" The fallacy here, of course, is that the ball had to land somewhere. We can only stand amazed at the improbability of the actual event if we specify it *a priori*: for example, if a blindfolded man spins himself round on the tee, hits the ball at random, and achieves a hole in one. That would be truly amazing, because the target destination of the ball is specified in advance.

Of all the trillions of different ways of putting together the atoms of a telescope, only a minority would actually work in some useful way. Only a tiny minority would have Carl Zeiss engraved on them, or, indeed, *any* recognizable words of any human language. The same goes for the parts of a watch: of all the billions of possible ways of putting them together, only a tiny minority will tell the time or do anything useful. And of course the same goes, *a fortiori*, for the parts of a living body. Of all the trillions of trillions of ways of putting together the parts of a body, only an infinitesimal minority would live, seek food, eat, and reproduce. True, there are many different ways of being alive - at least ten million different ways if we count the number of distinct species alive today - but, however many ways there may be of being alive, it is certain that there are vastly more ways of being dead!

We can safely conclude that living bodies are billions of times too complicated - too statistically improbable - to have come into being by sheer chance. How, then, did they come into being? The answer is that chance enters into the story, but not a single, monolithic act of chance. Instead, a whole series of tiny chance steps, each one small enough to be a believable product of its predecessor, occurred one after the other in sequence. These small steps of chance are caused by genetic mutations, random changes - mistakes really - in the genetic material. They give rise to changes in the existing bodily structure. Most of these changes are deleterious and lead to death. A minority of them turn out to be slight improvements, leading to increased survival and reproduction. By this process of natural selection, those random changes that turn out to be beneficial eventually spread through the species and become the norm. The stage is now set for the next small change in the evolutionary process. After, say, a thousand of these small changes in series, each change providing the basis for the next, the end result has become, by a process of accumulation, far too complex to have come about in a single act of chance.

For instance, it is theoretically possible for an eye to spring into being, in a single lucky step, from nothing: from bare skin, let's say. It is theoretically possible in the sense that a recipe could be written out in the form of a large number of mutations. If all these mutations happened simultaneously, a complete eye could, indeed, spring from nothing. But although it is theoretically possible, it is in practice inconceivable. The quantity of luck involved is much too large. The "correct" recipe involves changes in a huge number of genes simultaneously. The correct recipe is one particular combination of changes out of trillions of equally probable combinations of chances. We can certainly rule out such a miraculous coincidence. But it *is* perfectly plausible that the modern eye could have sprung from something almost the same as the modern eye but not quite: a very slightly less elaborate eye. By the same argument, this slightly less elaborate eye sprang from a slightly less elaborate eye still, and so on. If you assume a *sufficiently large number of sufficiently small differences* between each evolutionary stage and its predecessor, you are bound to be able to derive a full, complex, working eye from bare skin. How many intermediate stages are we allowed to postulate? That depends on how much time we have to play with. Has there been enough time for eyes to evolve by little steps from nothing?

The fossils tell us that life has been evolving on Earth for more than 3,000 million years. It is almost impossible for the human mind to grasp such an immensity of time. We, naturally and mercifully, tend to see our own expected lifetime as a fairly long time, but we can't expect to live even one century. It is 2,000 years since Jesus lived, a time span long enough to blur the distinction between history and myth. Can you imagine a million such periods laid end to end? Suppose we wanted to write the whole history on a single long scroll. If we crammed all of Common Era history into one metre of scroll, how long would the pre-Common Era part of the scroll, back to the start of evolution, be? The answer is that the pre-Common Era part of the scroll would stretch from Milan to Moscow. Think of the implications of this for the quantity of evolutionary change that can be accommodated. All the domestic breeds of dogs - Pekingeses, poodles, spaniels, Saint Bernards, and Chihuahuas - have come from wolves in a time span measured in hundreds or at the most thousands of years: no more than two meters along the road from Milan to Moscow. Think of the quantity of change involved in going from a wolf to a Pekingese; now multiply that quantity of change by a million. When you look at it like that, it becomes easy to believe that an eye could have evolved from no eye by small degrees.

It remains necessary to satisfy ourselves that every one of the intermediates on the evolutionary route, say from bare skin to a modern eye, would have been favored by natural selection; would have been an improvement over its predecessor in the sequence or at least would have survived. It is no good proving to ourselves that there is theoretically a chain of almost perceptibly different intermediates leading to an eye if many of those intermediates would have died. It is sometimes argued that the parts of an eye have to be all there together or the eye won't work at all. Half an eye, the argument runs, is no better than no eye at all. You can't fly with half a wing; you can't hear with half an ear. Therefore there can't have been a series of step-by-step intermediates leading up to a modern eye, wing, or ear.

This type of argument is so naive that one can only wonder at the subconscious motives for wanting to believe it. It is obviously not true that half an eye is useless. Cataract sufferers who have had their lenses surgically removed cannot see very well without glasses, but they are still much better off than people with no eyes at all. Without a lens you can't focus a detailed image, but you can avoid bumping into obstacles and you could detect the looming shadow of a predator.

As for the argument that you can't fly with only half a wing, it is disproved by large numbers of very successful gliding animals, including mammals of many different kinds, lizards, frogs, snakes, and squids. Many different kinds of tree-dwelling animals have flaps of skin between their joints that really are fractional wings. If you fall out of a tree, any skin flap or flattening of the body that increases your surface area can save your life. And, however small or large your flaps may be, there must always be a critical height such that, if you fall from a tree of that height, your life would have been saved by just a little bit more surface area. Then, when your descendants have evolved that extra surface area, their lives would be saved by just a bit more still if they fell from trees of a slightly greater height. And so on by insensibly graded steps until, hundreds of generations later, we arrive at full wings.

Eyes and wings cannot spring into existence in a single step. That would be like having the almost infinite luck to hit upon the combination number that opens a large bank vault. But if you spun the dials of the lock at random, and every time you got a little bit closer to the lucky number the vault door creaked open another chink, you would soon have the door open! Essentially, that is the secret of how evolution by natural selection achieves what once seemed impossible. Things that cannot plausibly be derived from very different predecessors *can* plausibly be derived from only slightly different predecessors. Provided only that there is a sufficiently long series of such slightly different predecessors, you can derive anything from anything else.

Evolution, then, is theoretically *capable* of doing the job that, once upon a time, seemed to be the prerogative of God. But is there any evidence that evolution actually has happened? The answer is yes; the evidence is overwhelming. Millions of fossils are found in exactly the places and at exactly the depths that we should expect if evolution had happened. Not a single fossil has ever been found in any place where the evolution theory would not have expected it, although this *could* very easily have happened: a fossil mammal in rocks so old that fishes have not yet arrived, for instance, would be enough to disprove the evolution theory.

The patterns of distribution of living animals and plants on the continents and islands of the world is exactly what would be expected if they had evolved from common ancestors by slow, gradual degrees. The patterns of resemblance among animals and plants is exactly what we should expect if some were close cousins, and others more distant cousins to each other. The fact that the genetic code is the same in all living creatures overwhelmingly suggests that all are descended from one single ancestor. The evidence for evolution is so compelling that the only way to save the creation theory is to assume that God deliberately planted enormous quantities of evidence to make it *look* as if evolution had happened. In other words, the fossils, the geographical distribution of animals, and so on, are all one gigantic confidence trick. Does anybody want to worship a God capable of such trickery? It is surely far more reverent, as well as more scientifically sensible, to take the evidence at face value. All living creatures are cousins of one another, descended from one remote ancestor that lived more than 3,000 million years ago.

The Argument from Design, then, has been destroyed as a reason for believing in a God. Are there any other arguments? Some people believe in God because of what appears to them to be an inner revelation. Such revelations are not always edifying but they undoubtedly feel real to the individual concerned. Many inhabitants of lunatic asylums have an unshakable inner faith that they are Napoleon or, indeed, God himself. There is no doubting the power of such convictions for those that have them, but this is no reason for the rest of us to believe them. Indeed, since such beliefs are mutually contradictory, we can't believe them all.

There is a little more that needs to be said. Evolution by natural selection explains a lot, but it couldn't start from nothing. It couldn't have started until there was some kind of rudimentary reproduction and heredity. Modern heredity is based on the DNA code, which is itself too complicated to have sprung spontaneously into being by a single act of chance. This seems to mean that there must have been some earlier hereditary system, now disappeared, which was simple enough to have arisen by chance and the laws of chemistry and which provided the medium in which a primitive form of cumulative natural selection could get started. DNA was a later product of this earlier cumulative selection. Before this original kind of natural selection, there was a period when complex chemical compounds were built up from simpler ones and before that a period when the chemical elements were built up from simpler elements, following the well-understood laws of physics. Before that, everything was ultimately built up from pure hydrogen in the immediate aftermath of the big bang, which initiated the universe.

There is a temptation to argue that, although God may not be needed to explain the evolution of complex order once the universe, with its fundamental laws of physics, had begun, we do need a God to explain the origin of all things. This idea doesn't leave God with very much to do: just set off the big bang, then sit back and wait for everything to happen. The physical chemist Peter Atkins, in his beautifully written book *The Creation*, postulates a lazy God who strove to do as little as possible in order to initiate everything. Atkins explains how each step in the history of the universe followed, by simple physical law, from its predecessor. He thus pares down the amount of work that the lazy creator would need to do and eventually concludes that he would in fact have needed to do nothing at all!

The details of the early phase of the universe belong to the realm of physics, whereas I am a biologist, more concerned with the later phases of the evolution of complexity. For me, the important point is that, even if the physicist needs to postulate an irreducible minimum that had to be present in the beginning, in order for the universe to get started, that irreducible minimum is certainly extremely simple. By definition, explanations that build on simple premises are more plausible and more satisfying than explanations that have to postulate complex and statistically improbable beginnings. And you can't get much more complex than an Almighty God!

Religion's misguided missiles

Promise a young man that death is not the end and he will willingly cause disaster

The following Richard Dawkins essay appeared in the popular U.K. news website,The Guardian on September 15, 2001, four days after the World Trade Center terrorist attack.

A guided missile corrects its trajectory as it flies, homing in, say, on the heat of a jet plane's exhaust. A great improvement on a simple ballistic shell, it still cannot discriminate particular targets. It could not zero in on a designated New York skyscraper if launched from as far away as Boston.

That is precisely what a modern "smart missile" can do. Computer miniaturisation has advanced to the point where one of today's smart missiles could be programmed with an image of the Manhattan skyline together with instructions to home in on the north tower of the World Trade Centre. Smart missiles of this sophistication are possessed by the United States, as we learned in the Gulf war, but they are economically beyond ordinary terrorists and scientifically beyond theocratic governments. Might there be a cheaper and easier alternative?

In the second world war, before electronics became cheap and miniature, the psychologist BF Skinner did some research on pigeon-guided missiles. The pigeon was to sit in a tiny cockpit, having previously been trained to peck keys in such a way as to keep a designated target in the centre of a screen. In the missile, the target would be for real.

The principle worked, although it was never put into practice by the US authorities. Even factoring in the costs of training them, pigeons are cheaper and lighter than computers of comparable effectiveness. Their feats in Skinner's boxes suggest that a pigeon, after a regimen of training with colour slides, really could guide a missile to a distinctive landmark at the southern end of Manhattan island. The pigeon has no idea that it is guiding a missile. It just keeps on pecking at those two tall rectangles on the screen, from time to time a food reward drops out of the dispenser, and this goes on until... oblivion.

Pigeons may be cheap and disposable as on-board guidance systems, but there's no escaping the cost of the missile itself. And no such missile large enough to do much damage could penetrate US air space without being intercepted. What is needed is a missile that is not recognised for what it is until too late. Something like a large civilian airliner, carrying the innocuous markings of a well-known carrier and a great deal of fuel. That's the easy part. But how do you smuggle on board the necessary guidance system? You can hardly expect the pilots to surrender the left-hand seat to a pigeon or a computer.

How about using humans as on-board guidance systems, instead of pigeons? Humans are at least as numerous as pigeons, their brains are not significantly costlier than pigeon brains, and for many tasks they are actually superior. Humans have a proven track record in taking over planes by the use of threats, which work because the legitimate pilots value their own lives and those of their passengers.

The natural assumption that the hijacker ultimately values his own life too, and will act rationally to preserve it, leads air crews and ground staff to make calculated decisions that would not work with guidance modules lacking a sense of self-preservation. If your plane is being hijacked by an armed man who, though prepared to take risks, presumably wants to go on living, there is room for bargaining. A rational pilot complies with the hijacker's wishes, gets the plane down on the ground, has hot food sent in for the passengers and leaves the negotiations to people trained to negotiate.

The problem with the human guidance system is precisely this. Unlike the pigeon version, it knows that a successful mission culminates in its own destruction. Could we develop a biological guidance system with the compliance and dispensability of a pigeon but with a man's resourcefulness and ability to infiltrate plausibly? What we need, in a nutshell, is a human who doesn't mind being blown up. He'd make the perfect on-board guidance system. But suicide enthusiasts are hard to find. Even terminal cancer patients might lose their nerve when the crash was actually looming.

Could we get some otherwise normal humans and somehow persuade them that they are not going to die as a consequence of flying a plane smack into a skyscraper? If only! Nobody is that stupid, but how about this - it's a long shot, but it just might work. Given that they are certainly going to die, couldn't we sucker them into believing that they are going to come to life again afterwards? Don't be daft! No, listen, it might work. Offer them a fast track to a Great Oasis in the Sky, cooled by everlasting fountains. Harps and wings wouldn't appeal to the sort of young men we need, so tell them there's a special martyr's reward of 72 virgin brides, guaranteed eager and exclusive.

Would they fall for it? Yes, testosterone-sodden young men too unattractive to get a woman in this world might be desperate enough to go for 72 private virgins in the next.

It's a tall story, but worth a try. You'd have to get them young, though. Feed them a complete and self-consistent background mythology to make the big lie sound plausible when it comes. Give them a holy book and make them learn it by heart. Do you know, I really think it might work. As luck would have it, we have just the thing to hand: a ready-made system of mind-control which has been honed over centuries, handed down through generations. Millions of people have been brought up in it. It is called religion and, for reasons which one day we may understand, most people fall for it (nowhere more so than America itself, though the irony passes unnoticed). Now all we need is to round up a few of these faith-heads and give them flying lessons.

Facetious? Trivialising an unspeakable evil? That is the exact opposite of my intention, which is deadly serious and prompted by deep grief and fierce anger. I am trying to call attention to the elephant in the room that everybody is too polite - or too devout - to notice: religion, and specifically the devaluing effect that religion has on human life. I don't mean devaluing the life of others (though it can do that too), but devaluing one's own life. Religion teaches the dangerous nonsense that death is not the end.

If death is final, a rational agent can be expected to value his life highly and be reluctant to risk it. This makes the world a safer place, just as a plane is safer if its hijacker wants to survive. At the other extreme, if a significant number of people convince themselves, or are convinced by their priests, that a martyr's death is equivalent to pressing the hyperspace button and zooming through a wormhole to another universe, it can make the world a very dangerous place. Especially if they also believe that that other universe is a paradisical escape from the tribulations of the real world. Top it off with sincerely believed, if ludicrous and degrading to women, sexual promises, and is it any wonder that naive and frustrated young men are clamouring to be selected for suicide missions?

There is no doubt that the afterlife-obsessed suicidal brain really is a weapon of immense power and danger. It is comparable to a smart missile, and its guidance system is in many respects superior to the most sophisticated electronic brain that money can buy. Yet to a cynical government, organisation, or priesthood, it is very very cheap.

Our leaders have described the recent atrocity with the customary cliche: mindless cowardice. "Mindless" may be a suitable word for the vandalising of a telephone box. It is not helpful for understanding what hit New York on September 11. Those people were not mindless and they were certainly not cowards. On the contrary, they had sufficiently effective minds braced with an insane courage, and it would pay us mightily to understand where that courage came from.

It came from religion. Religion is also, of course, the underlying source of the divisiveness in the Middle East which motivated the use of this deadly weapon in the first place. But that is another story and not my concern here. My concern here is with the weapon itself. To fill a world with religion, or religions of the Abrahamic kind, is like littering the streets with loaded guns. Do not be surprised if they are used.

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Extended Phenotype – But Not *Too* Extended. A Reply to Laland, Turner and Jablonka

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I am grateful to the three commentators for their thoughtful and penetrating remarks, and to the Editor for commissioning them. All three have forced me to think, re-opening neural pathways that had suffered neglect as I turned to other things in the years since *The Extended Phenotype* (henceforth *EP*) was published. Their essays raise so many interesting points, it would take another book to reply to them properly. Instead, on the basis that it is better to say a few things thoroughly than lots sketchily, I shall concentrate on what I take to be each author's central argument.

J. Scott Turner and Kevin Laland both, in their different ways, want to go further than me in extending the phenotype. Or so they see it. I am not so sure that further is the right word. Progress implies movement in a useful direction, whereas their extensions – of the organism, and into niche creation – occasionally reminded me of Stephen Leacock's knight who jumped on his horse and galloped off in all directions. I don't intend that flippantly or disrespectfully. The relevant point about the extended phenotype is that it is a *disciplined* extension. There are lots of other tempting 'extensions', which sound similar but take us off in misleading directions. I have always fought shy of misapplying the phrase to a profligate range of apparently plausible extensions.

To take a more extreme example than these commentators consider, when I am asked by lay people (as I frequently am) whether buildings count as extended phenotypes, I answer no, on the grounds that the success or failure of buildings does not affect the frequency of architects' genes in the gene pool. Extended phenotypes are worthy of the name only if they are candidate adaptations for the benefit of alleles responsible for variations in them. I might admit the theoretical possibility of generalising to other kinds of replicators such as memes (or something 'epigenetic' that Eva Jablonka might be able to explain but I wouldn't), in which case my 'no' answer might be softened. But it is enough of a problem already, getting my more hard-headed scientific colleagues to accept the extended phenotype, without arousing their active hostility by mentioning memes (which many see as simplistic) or 'epigenetic

inheritance systems' (which some might write off as obscurantist). I shall return to the important point, which I enthusiastically accept, that replicators do not have to be made of DNA in order for the logic of Darwinism to work.

Laland speaks, I suspect, for all three authors when he espouses cyclical causation. He quotes me as saying

> There are causal arrows leading from genes to body. But there is no causal arrow leading from body to genes.

Laland, who disagrees, generously wants to absolve me from responsibility for this, saying that he is quoting out of context. But I am happy to stand by it. 'Cyclical causation' leaves me cold. I must, however, make very clear that I mean causation statistically. Experimentally induced changes in bodies are never correlated with changes in genes, but changes in genes (mutations) are sometimes correlated with changes in bodies (and all evolution is the consequence). Of course most mutations occur naturally rather than experimentally, but (because corrrelation can't establish causation) I need to focus on 'experimentally induced' in order to pin down the direction of the causal arrow. It is in this statistical sense that development's arrow goes only one way. Attempts to argue for a reverse arrow recur through the history of biology, and always fail except in unimportant special-pleading senses.

Sterelny, Smith and Dickerson (1996), follow Griffiths and Gray in saying "Most acorns rot, so acorn genomes correlate better with rotting than with growth". But this is dead wrong. It misunderstands the very meaning of correlation which is, after all, a statistical technical term. Admitting that most genomes rot, the relevant question is whether *such variation as there may be* in acorn genomes correlates with *such variation as there may be* in tendency to rot. It probably does, but that isn't the point. The point is that the question of covariance is the right question to ask. Sterelny and Kitcher (1988) in their excellent paper on 'The Return of the Gene' are very clear on the matter. Think variation. Variation, variation, variation. Heritable variation; covariation between phenotype as dependent variable, and putative replicator as independent variable. This has been my *leitmotif* as I read all three commentators, and it will be my refrain throughout my reply.

Laland's main contribution to our debate is 'niche construction'. The problem I have with niche construction is that it confuses two very different impacts that organisms might have on their environments. As Sterelny (2000) put it,

> Some of these impacts are mere effects; they are byproducts of the organisms's way of life. But sometimes we should see the impact of organism on environment as the organism *engineering* its own environment: the environment is altered in ways that are adaptive for the engineering organism.

Niche construction is a suitable name only for the second of these two (and it is a special case of the extended phenotype). There is a temptation, which I regard as little short of pernicious, to invoke it for the first (byproducts) as well. Let's call the first type by the more neutral term, 'niche changing', with none of the adaptive implications of niche construction or – for that matter – of the extended phenotype.

A beaver dam, and the lake it creates, are true extended phenotypes insofar as they are adaptations for the benefit of replicators (presumably alleles but conceivably something else) that statistically have a causal influence on their construction. What crucially matters (here's the *leitmotif* again) is that *variations* in replicators have a causal link to *variations* in dams such that, over generations, replicators associated with good dams survive in the replicator pool at the expense of rival replicators associated with bad dams. Note what a stringent requirement this is. Although it is not necessary that we should already have evidence for the replicator-phenotype covariance, extended phenotype language commits us to a can only have come about through replicator-phenotype covariance. The beaver's dam is as much an adaptation as the beaver's tail. In neither case have we done the necessary research to show that it results from gene selection. In both, we have strong plausibility grounds to think it is. The same is not true – would not even be claimed by Laland and his colleagues – of most of their proposed examples of niche construction.

See how different is the 'pernicious' sense of niche construction, the byproduct that I'd prefer to sideline as 'niche changing'. Here, the dam alters the environment of the future, in some way that impinges on the life and wellbeing of beavers in general, and probably others too. Not particularly the welfare of the beavers that built the dam, not even of their children or grandchildren. The dam is good for beaverdom, and more. Beavers, frogs, fishes and marsh marigolds all benefit from a beaver-induced flooding of their niche. This is too loose and vague to count as a true extended phenotype, or as true niche construction. The deciding question is 'Who benefits?' And the reason it matters is that we have a Darwinian explanation of the dam only if dam-friendly alleles of the dam builders themselves benefit at the expense of alternative alleles.

I have no wish to downplay the importance of niche changing. It is a fair description of many important biological events, ranging from the irreversible oxygenation of Earth's early atmosphere by green bacteria and now by plants, to the greening of deserts by ecological successions of plants climaxing in dense forest communities, and including Scott Turner's *heuweltjies* (a fascinating example, of which I had been ignorant).

Most biologists would accept that the beaver dam is an evolved adaptation for the benefit of the genes of the responsible beaver. It would be a bold scientist (James Lovelock, perhaps) who would suggest that the oxygenation of the atmosphere by plants is an adaptation for the benefit of something. The oxygenation of the atmosphere is a hugely important niche change, and woe betide any creature, including any plant, that fails to adapt to it. But the presence of oxygen is nobody's adaptation (or at least, you'll have your work cut out if you want to argue that it is). It is a byproduct of plant biochemistry to which all living creatures, plants included, must adapt. Beaver dams may or may not benefit other beavers, or fishes or water beetles or pondweeds, but such diffuse and unfocused benefits cannot explain why they are there. The only benefits that can be adduced in Darwinian explanation of dams are benefits to the alleles (or other responsible replicators) of the particular beavers that build them. Otherwise, natural selection could not have shaped their evolution. Long-term consequences of niche changing are interesting and important, but they do not provide a Darwinian explanation for why animals change their niches.

Laland pays some lip service to this point when he speaks of ecological inheritance, and says that it resembles the inheritance of territory or property. Local exclusiveness is indeed a vital ingredient of true niche construction. As long as beavers have a high chance passing their lake on to their own grandchildren rather than to somebody else's grandchildren, there is at least a chance of making a workable Darwinian model of niche construction. But the rhetoric of niche construction neglects to follow the lip service, and we are left believing it to be a larger and a grander theory than it really is. Those aspects of niche construction theory that work are already included within extended phenotype theory. Those aspects that don't fit within existing extended phenotype theory don't work.

Don't work as Darwinian adaptations, that is. They can still be interesting in other ways. Earthworms are mentioned by both Laland and Turner, and Laland's splendid 'accessory kidneys' are a gift to Turner and his 'extended organism'. Earthworms radically change the environment in which they, and all other soil organisms including – significantly – rival earthworms live. Again, we certainly have niche alteration but, please, not niche construction until a lot more work has been done to establish this onerous claim.

Ecological succession is a form of niche changing – not niche construction – which follows a repeatable, regular pattern. A desert is colonised by weeds, which then change conditions sufficiently to allow the subsequent invasion by an orderly succession of plants and animals, each wave altering niches in ways that favour the next wave, culminating in a climax forest. But, important and repeatable as ecological succession is, it is not a Darwinian

adaptation on the part of prior member of the succession on behalf of later members. Rather, natural selection within the gene pools of later members of the succession favours those individuals that take advantage of the conditions inadvertently set up by earlier members. The climax forest is a consequence of colonisation by weeds decades or even centuries earlier. The forest is not an extended phenotype of the weeds' genes, nor is it helpful or illuminating to call it a niche constructed by the weeds. The same can be said of the repeatably regular pattern of development of coral reefs, in which generations of polyps build literally on the environment provided by centuries of dead predecessors, and form the foundation – literally and metaphorically – for the marine equivalent of a climax forest community.

Moving on from ecological succession to longer-term processes that look a bit like niche construction, coevolutionary arms races are the outstanding example (Dawkins and Krebs 1979). Predators impose new selection pressures on prey, which respond in evolutionary time such that future generations of prey impose changed selection pressures on future generations of predators. The coevolutionary positive feedback spirals that result are responsible for the most advanced and stunning illusions of design that the natural world has to offer. Again this is a case of animals changing future niches, and changing them in fascinating ways, but again it isn't niche construction, and no helpful purpose is served by lumping it with beaver dams or ecological succession. Understanding requires us to respect clear distinctions.

I don't denigrate niche changing as an important biological phenomenon. But it is not the same thing as true niche construction. Nothing but confusion will result from treating one as a continuation of the other. Since this seems to be a misunderstanding that is eagerly waiting to happen, niche construction is a phrase that should be abandoned forthwith.

That's all I want to say about niche construction. Now, the extended organism, which is J Scott Turner's main contribution to our debate. Turner, like Laland, is aware of the distinction between benefit to the agents responsible for a phenotype, and benefit to the world at large. But, as with Laland, his enthusiasm is in danger of misleading others into forgetting the distinction.

Turner, like Jablonka as we shall see, thinks I am too much of a genetic triumphalist. For the moment I shall leave that on one side while I focus on the wonderful examples of would-be extended organisms that Turner offers us from his own work on termites. Yes, the *Macrotermes* nest, with its underground living and brooding chambers and its overground ventilation apparatus, has many of the attributes of an organism. And yes, it is an intriguing conceit that the fungi are cultivating the termites, rather

than the other way around. Indeed, I said something pretty similar about cellulose-digesting gut microbes in *EP* (p. 208):

> Could the evolution of eusociality in the Isoptera be explained as an adaptation of the microscopic symbionts rather than of the termites themselves?

Once again, note that the extended phenotype is a *disciplined* hypothesis. Speculative as my suggestion was, it was a very specific and tightly limited speculation. Implicitly it postulated *alleles* in microorganisms (or fungi to take in Turner's hypothesis) which *vary* in their effects upon termite social behaviour (or mounds). The fact that there is no actual evidence for either speculation need not worry us at this stage. The point is to be precise about the genetic nature of the speculation. Adaptive hypotheses, however wild and speculative, must not be vaguely Panglossian but precisely limited to specified alleles (or other replicators) which *vary* and which exert a *causal* influence on *variation* in the phenotype of interest.

Let's apply these rigorous standards to the hypothesis that a termite mound is an extended organism. We shall conclude in favour, but it is important to make the case properly, in what I have called a disciplined manner. We shall take for granted the physiological, homeostatic and thermodynamic arguments put by Turner – not because they are unimportant but because he has made them so well. Instead, we concentrate on the genetics (using genes to stand for other conceivable replicators). Mound morphology is sure to be influenced by a number of genes, acting via mound embryology which, in the terms of our discussion, is another name for termite behaviour. These genes are to be found in the cells of many different organisms (using 'organism' in the conventional, non-extended sense). They include genes in the cell nuclei of numerous individual worker termites. They also might include genes in fungi, genes in gut symbionts, and genes in mitochondria or other cytoplasmic elements in the cells of termites, fungi or gut symbionts. So, we potentially have a rich pandemonium of genetic inputs to our mound phenotype, coming at it from as many as three kingdoms.

For my money, the analogy of mound with organism stands up well. The fact that we have a heterogeneously sourced genetic input to the embryology of the phenotype doesn't matter. Lots of genes affect each aspect of my bodily phenotype, including, for all I know, mitochondrial genes. My 'own' nuclear genes tug me in more or less different directions, and my phenotype is some sort of quantitative polygenic compromise. So that is not a difference that might stop the mound being an organism. What, then, is the prime characteristic of an organism? It is that, at least to a quantitatively appreciable extent, all its genes are passed on to the next generation together, in a small 'bottlenecked' propagule. The rationale for this is given in *EP*,

especially Chapter 12, 'Host phenotypes of parasite genes' and Chapter 14, 'Rediscovering the Organism', and I shall not repeat it here. Instead, let's go straight to the termite mound to see how well it holds up. Pretty well. Each new nest is founded by a single queen (or king and queen) who then, with a lot of luck, produces a colony of workers who build the mound. The founding genetic injection is, by the standards of a million-strong termite colony, an impressively small bottleneck. The same is, at least quantitatively, true of the gut symbionts with which all termites in the new nest are infected by anal licking, ultimately from the queen – the bottleneck. And the same is quantitatively true of the fungus, which is carefully transported, as a small inoculum, by the founding queen from her natal nest. All the genes that pass from a parent mound to a daughter mound do so in a small, shared package. By the bottleneck criterion, the termite mound passes muster as an extended organism, even though it is the phenotype of a teeming mass of genes sitting in many thousands of workers.

I won't miss an opportunity to emphasise (though again I shall not repeat the full argument from *EP)* that every organism (conventionally defined) is already a symbiotically cooperating union of its 'own' genes. What draws them, in a Darwinian sense, to cooperate is again 'bottlenecking': a shared statistical expectation of the future. This shared expectation follows directly from the method of reproduction, according to which all of an organism's 'own' nuclear genes, and its cytoplasmic genes for good measure, pass to the next generation in a shared propagule. To the extent that this is true of parasite genes (for example bacteria that travel inside the host's egg), to that very same extent aggressive parasitism will give way in evolutionary time to amicable and cooperative symbiosis. The parasite genes and the host genes see eye to eye on what is an optimum host phenotype. Both 'want' a host phenotype that survives and reproduces. But to the extent that parasite genes pass to their own next generation via some sideways route which is not shared with those of the host genes, to that same extent the parasite will tend to be vicious and dangerous. In such cases, the optimum phenotype from the parasite genes' point of view may well be dead – perhaps having burst in a cloud parasite spores. All our 'own' genes are mutually parasitic, but they are amicably cooperative parasites because their shared route to the future in every generation leads them to 'see eye to eye' on the optimal phenotype.

A termite mound, then, is a good extended organism. A *heuweltjie*, by my reading of Turner's description, is not. It is more like a forest or a coral reef. The genes that contribute to the putative heuweltjie phenotype don't cooperate, because they do not have a statistical expectation of sharing a propagule from the present heuweltjie to the next. Only the contingent centred around the termite genes has that shared expectation. The rest will

join the club later, from different sources, which means that, in the sense I am expounding, it is not a club. Because termite genes, with their fellow travellers, bottleneck their way from mound to mound, we can reasonably think about a form of natural selection which chooses among mounds as extended pheontypes, with adaptive consequences in an evolutionary succession of progressively improving mounds. The same will not be true of a putative natural selection of heuweltjies. Hence my statement that a heuweltjie is not a good extended organism. As in the case of Laland and his niche construction, my request to Turner is to be critical and disciplined with his notion of the extended organism. In his case, apply the bottleneck test.

At this point, I have to pick Turner up on his outrageous statement that "most would agree that the central dogma is essentially dead." It is important to do so because I suspect that many people (perhaps including present commentators who are drawn to 'cyclical causation' and similar notions) have a kind of poetic bias against Francis Crick's central dogma. This may be partly, and understandably, because of Crick's unfortunate choice of the word 'dogma', as opposed to, say, 'hypothesis' or 'theorem'. Crick's own explanation is endearing, as recounted in an interview with Horace Judson (1979). Judson asked him why he had used the word dogma and Crick replied that, because of his religious upbringing, he thought a dogma was a word for something "for which there was *no reasonable evidence.*" He had since been told by Jacques Monod that it means "something which a true believer *cannot doubt*." "You see" Crick roared with laughter as he confided in Judson, "I just didn't *know* what dogma *meant*!" Actually, the Oxford English Dictionary could be used to support either meaning.

The central dogma has been expressed in three versions, whose differences can admittedly lead to confusion: –

1. "Once information has passed into protein, *it cannot get out again*." This is Francis Crick's original wording, at the 1957 meeting of the Society for Experimental Biology and it is, as one would expect, completely clear. Note the prescience with which, long before reverse transcription was discovered, Crick in effect anticipated its irrelevance to his dogma.

> . . . the transfer of information from nucleic acid to nucleic acid, or from nucleic acid to protein may be possible, but transfer from protein to protein, or from protein to nucleic acid is impossible. Information means here the *precise* determination of sequence, either of bases in the nucleic acid or of amino acid residues in the protein (Crick 1957, quoted in Judson 1979).

In this version the central dogma has never been violated and my bet is that it never will. The genetic code, whereby nucleotide sequences are translated into amino acid sequences, is irreversible.

2. “DNA makes RNA makes protein.” This sounds pithy and clever, but it is too pithy and not clever enough. Unfortunately, it is the textbook version that students learn. But it is a summary of research findings, not a theoretical principle like Crick’s ‘dogma’. It is technically violated by reverse transcription but, as we shall see, the fact is trivial and misses the whole point of the dogma.

3. “Embryology is irreversible.” This third version is another way of saying that acquired characteristics are not inherited. It is not particularly molecular in its domain, and it owes more to Weismann than Crick, but it is interesting in being closer to 1 (theoretical principle) than to 2 (summary of known facts, now trivially violated). This version, too, has never been convincingly violated, despite many attempts.

Version 2 is disproved by reverse transcription, but this is a violation of the dogma only if we think the dogma was ever intended to apply to *both* stages of the process: transcription (DNA to RNA) as well as translation (polynucleotide to protein). But such a dogma would have been foolhardy, lacking any basis in theory, and it was explicitly excluded by Crick, with the prescience I have already praised (“the transfer of information from nucleic acid to nucleic acid”). The only ground Crick, or anybody else, ever had for confidence in his central dogma is that the information in a protein is inaccessibly buried inside the knot which the protein ties in itself – *must* tie if it is to perform its role as an enzyme. DNA is not knotted, which is why it is a lousy enzyme but very good at getting its information transcribed (into RNA, as it happens). RNA can tie itself in a kind of knot, enough to secure some sort of enzyme function (which is why some people favour it for a primitive enzyme role as well as a primitive replicator role in theories of the origin of life). But RNA doesn’t always get knotted, which is why it is good at getting its information read and translated into protein. It therefore should have surprised nobody that RNA’s information can sometimes be reverse transcribed back into DNA. Why should it not, given that it maps DNA information one to one, and it is necessarily accessible otherwise it could never be translated into protein? If Version 1, on the other hand, were ever disproved (which I doubt) it would only be by reverse translation of a structural protein like collagen or silk – un-knotted and therefore incapable of functioning as an enzyme.

Prions, contrary to widespread misunderstanding, do not violate Crick’s careful formulation of his dogma. They are replicators after a fashion, in that their alternative conformations are infectious. But the amino acid sequence of a prion is not reverse-translated into the appropriate codon sequence of a polynucleotide (look again at Crick’s prudent wording). Nor is the sequence of amino acids copied by another polypeptide chain. All that happens is that, of the alternative three dimensional conformations of a given polypeptide

sequence, one can, by its proximity, convert another existing molecule to its own shape. Nobody has ever realistically suggested that the amino acid sequence of a prion comes from any source other than DNA.

Dogma 3, the Weismannian or anti-Lamarckian pre-molecular version, is of course, the subject of old arguments, and I shall not get into all that here because it is not what Turner was talking about anyway. I'll just point out that it is a sort of whole-organism version of Crick's molecular dogma, and it is based on a similar theoretical principle. Just as amino acid sequences are inaccessibly buried in a protein, so the genetic instructions that program the development of a body are inaccessibly buried in the body itself. This is not just an empirical fact, which could be disproved at any moment by a Lamarckian finding such as a non-fraudulent case of the midwife toad. It follows from the deeper principle that embryology is not preformationistic. This is the old point about blueprints being reversible, recipes not (*EP* p. 174: 'The Poverty of Preformationism'). You can reconstruct a blueprint from a house, but not a recipe from a cake, an image that I inadvertently borrowed from my friend Patrick Bateson. Bateson's name, by the way, reminds me of my astonishment that Eva Jablonka is not the only author to sympathize with his superficially amusing but deeply misleading suggestion that a gene is a nest's way of making another nest. I shall return to this at the end.

To conclude on the central dogma, that limited part which is essentially dead (RNA cannot be reverse transcribed) should never have been born in the first place. That part of the dogma which deserved to be enunciated (and actually was enunciated by Crick) is most certainly not dead, not essentially dead, not even the tiniest bit ailing.

Let me now turn to Eva Jablonka. She, like the other two commentators, has read *EP* with flattering attention, and I am grateful for her, and their, clear disavowal of several potential misunderstandings. Genetic determinism does not follow from gene selectionism. Nor does naïve adaptationism. She is also admirably clear that "when geneticists talk about 'genes for', they are talking about genetic *differences* that make a *difference* to the phenotype." I suspect that she, like Turner, wants to have nothing to do with what he calls 'genetic triumphalism'. I agree, insofar as the 'gene' role in Darwinian models does not have to be played by DNA. If I am a triumphalist, it is a replicator triumphalist. I am happy to go along with what Sterelny (2000) has dubbed 'the extended replicator'. Indeed, I was at some pains to extend the replicator myself, in *EP*, listing several of the alternative replicators mentioned by today's three commentators: paramecium cilia, and memes, for instance. I would certainly have included prions if they had been discovered then. Jablonka is right when she says:

> Following the fortunes of heritably variable phenotypic traits in populations is common practice in evolutionary biology. We measure the genetic component of the variance in a trait in a population; models of phenotypic evolution are regularly constructed (e.g. most game theoretical models); and paleontological data, which is mostly based on morphological traits, is an accepted source of insights about evolution. Since for an entity to count as a 'fitness bearer' – a unit of adaptive evolution – it has to show (frequent) heritable variation in fitness, variant phenotypic traits are much better candidates than genes for this role.

I agree. But Jablonka should not be *surprised* that I agree. I devoted a chapter, 'Selfish Wasp or Selfish Strategy' to developing precisely the notion that a Darwinian replicator does not have to be specified as DNA, but can be a Maynard Smithian 'strategy' defined in a minimalist 'like begets like' fashion. Presumably DNA is involved in practice, but it is not a specified part of the reasoning. Jablonka's 'heritably varying phenotypic trait' is close to Williams's classic definition of the 'gene', which was the same sense in which I later called it 'selfish'.

> If there is an ultimate indivisible fragment it is, by definition, 'the gene' that is treated in the abstract definitions of population genetics (Williams 1966).

The Williams gene is only incidentally made of DNA. He later (1992) called the generalised version (what I would call a replicator) a codex, adding, "A gene is not a DNA molecule; it is the transcribable information coded by the molecule." I agree with Sterelny (and I am sure Williams would too):

> My own view is that DNA-based transmission of similarity *is* of fundamental significance. But that is not built into the structure of the theory.

Quite so. If Jablonka manages to convince the scientific community that some sort of complex feedback system of developmental cycles constitutes a true replicator, over and above its DNA content, I would be happy to embrace it. But, for the third time and at the risk of seeming pedantic, I insist on tight discipline. The criterion for recognizing a true replicator for a Darwinian model is a rigorous one. The putative replicators must vary in an open-ended way; the variants must exert phenotypic effects that influence their own survival; the variants must breed true and with high fidelity such that, when natural selection chooses one rather than its alternative, the impact persists through an indefinitely large number of generations (more precisely, survives at a high enough rate to keep pace with mutational degredation). If there is something other than DNA that meets these criteria, let us by all means include it, with enthusiasm, in our Darwinian models. But it really

must meet those criteria. Sterelny (2000) has a similar list, which he calls Hoyle Conditions because he imagines tailoring a form of life to colonise an empty world from outer space.

I am interested in the possibility that Jablonka really has a good new candidate for a true replicator, but I have to say that the use of the word 'epigenetic' makes for an unpropitious start – associated as it (no doubt unfairly) has become with obscurantism among biologists.[1] Epigenetic should be reserved for its true meaning as a historical school of embryology, hard to define except as a nebulous antonym of preformationist – which is not nebulous, is easy to define,and clearly wrong. If you want to propose an alternative replicator, extragenetic, paragenetic or quasigenetic might all be happier choices than epigenetic – not on grounds of strict etymology but because epigenetic is weighed down by inappropriate historical associations. A meme might be a quasigenetic replicator. A prion is perhaps a paragenetic replicator. Both fall down on some, but not all, of my criteria. Prions fail on the criterion of open-ended variation: the repertoire of variants for a given prion is limited to two. And memes – no, for heaven's sake don't let's get into memes now: I'll save them up to make a more worthwhile point, in a moment.

Jablonka's use of Waddington's canalization is potentially interesting (Waddington, numerous references, e.g. 1977). This isn't quite how she puts it, but canalization could play a 'self-normalizing' role. Let me explain self-normalizing, using memes in the way they are perhaps best used – by analogy. When I was a small boy at boarding school, we had to take turns in saying a goodnight prayer, kneeling up on the ends of our beds with our hands together. I can now reconstruct that the original prayer must have been that popular Evensong Collect, "Lighten our darkness, we beseech Thee O Lord, and by Thy great mercy defend us from all the perils and dangers of this night. . . ." But we only ever heard it said by each other, and none of us had a clue what most of the words meant. By the time I arrived at the school, the first line had become – and I inherited it, garbled it further, and passed it on – something like this: "Lutnar darkny sweep seech Theo Lord. . . ."

The childhood game of Chinese Whispers (American children call it Telephone) is a good model for such degradation of messages handed down over memetic 'generations'. Twenty (say) children are lined up, and a message whispered into the ear of the first. She repeats it in the ear of the second, and it passes on down the line until the twentieth child finally speaks it aloud to the assembled company – who are amused or dumbfounded at how much it has degenerated when compared with the original. As experimental memeticists we might find Chinese Whispers a useful test bed. We would compare the fidelity of various classes of message. Compare, for example, a message in a

language unknown to the children with a message they can understand. My school prayer was a sort of inadvertent running of this experiment.

When a child listens to a message and passes it on, there are two ways he can do it, one being ‘normalizing’ and the other not. The non-normalizing method is to imitate the sounds, phoneme by phoneme. That is approximately what the members of my dormitory were doing with ‘Lighten our darkness’. The normalizing method is to treat the message, not as a set of phonemes to be imitated, but as a set of words to be looked up in a mental dictionary and then re-rendered in the child’s own accents.

Cananalizing is not synonymous with digitizing but it has a similar effect. Digital codes such as DNA are protected from continuously distributed degradation, while at the same time becoming vulnerable to discrete error. Both are potential normalizing agents. Normalization is even more clearly illustrated by another meme which spread as an epidemic or craze at my father’s school, and with which I re-infected the same school when I went there 26 years later. It consisted of the instructions for making an origami Chinese Junk.

> It was a remarkable feat of artificial embryology, passing through a distinctive series of intermediate stages: catamaran with two hulls, cupboard with doors, picture in a frame, and finally the junk itself, fully seaworthy or at least bathworthy, complete with deep hold, and two flat decks each surmounted by a large, square-rigged sail (Dawkins 1999).

One could imagine a version of Chinese Whispers in which what passed down the line was a hands-on demonstration of this particular skill. Unlike a drawing of a junk, which would degrade horribly down the line, the origami instructions have a good chance of making it, intact, to the twentieth child, for the reason that they are self-normalising. Here are the first five instructions for making a Chinese junk.

1. Take a square sheet of paper and fold all four corners exactly into the middle.
2. Take the reduced square so formed, and fold one side into the middle.
3. Fold the opposite side into the middle, symmetrically.
4. In the same way, take the rectangle so formed, and fold its two ends into the middle.
5. Take the small square so formed, and fold it backwards, exactly along the straight line where your last two folds met.

And so on, through 20 or 30 instructions of this kind. These instructions, though I would not wish to call them digital, are potentially of very high fidelity, just as if they were digital. This is because they all

> make reference to idealised tasks like 'fold the four corners exactly into the middle'. If the paper is not exactly square, or if a child folds ineptly so that, say, the first corner overshoots the middle and the fourth corner undershoots it, the junk that results will be inelegant. But the next child in the line will not copy the error, for she will assume that her instructor *intended* to fold all four corners into the exact centre of a perfect square. The instructions are self-normalising. The code is error correcting (Dawkins loc. cit.)

I hope the analogy to Waddingtonian canalization, and Jablonka's usage of it, is becoming clearer. A canalized embryology is resistant to change. Resistant, at least, to small, continuously distributed change, although large changes can kick Waddington's rolling ball out of the groove into a neighbouring one. Even this subtlety is well covered by the origami analogy:

> I haven't done it, but I will make the following confident prediction, assuming that we run the experiment many times on different groups of 20 children. In several of the experiments, a child somewhere along the line will forget some crucial step in the skill taught him by the previous child, and the line of phenotypes will suffer an abrupt macromutation which will presumably then be copied to the end of the line, or until another discrete mistake is made. The end result of such mutated lines will not bear any resemblance to a Chinese junk at all. But in a good number of experiments the skill will correctly pass all along the line, and the 20th junk will be no worse and no better, on average, than the first junk. If we then lay the 20 junks out in order, some will be more perfect than others, but imperfections will not be copied on down the line. If the fifth child is hamfisted and makes a clumsily asymmetrical or floppy junk, his quantitative errors will be corrected if the sixth child happens to be more dexterous (Dawkins loc. cit.).

The twenty junks will not exhibit a progressive deterioration, as they would in a game in which each child was asked to imitate a *drawing* done by the preceding child. In the light of this memetic analogy, I take it that Jablonka is proposing that canalization increases the *fidelity* of her putative replicator by resisting change, at least up to the point where the Waddingtonian 'rolling ball' is kicked into a neighbouring channel. If I am right, it is a worthwhile suggestion, which needs to be worked out more thoroughly. My hunch is that it will come to nothing, but it is interesting, nevertheless. It could have the makings of a new kind of replicator theory.

I said that I'd return to Pat Bateson and The Selfish Nest. Jablonka sympathizes with Bateson's opinion that the developmental cause-effect relationship between genes and phenotypes is circular, and that a gene can

therefore be thought of as a nest's way of making another nest. Sterelny, Smith and Dickerson (1996) go so far as to say, "Bateson was right"! No, Bateson was not right, he wasn't even close to being right, for the reasons I gave in *EP*, reasons mentioned by Jablonka, and by Sterelny et al. but, to my bafflement, not accepted by them.

> Dawkins rejected this idea on the grounds that variation is not transmitted [the *leitmotif* again, RD]. Whatever the merits of The Selfish Nest as an evolutionary hypothesis, it cannot be rejected on those grounds. First, because Dawkins here appeals to the same criterion used to exclude asexual organisms as replicators; a criterion unsatisfactory on other grounds. Second, it is not in general true. Environmentally altered patterns in cilia are inherited through fission. . . . Variation in both nesting materials and nest siting can be transmitted (Sterelny, Smith and Dickerson 1996).

My grounds for excluding asexual organisms as replicators were, in my opinion, very satisfactory. I'll reply to what Sterelny et al. went on to say:

> Dawkins appealed to fidelity to argue that asexual organisms are not replicators [*EP* p. 97]. An aphid that loses one of its legs will still give birth to six-legged offspring. . . . This criterion backfires against genetic replication. Many changes in the germline genes are not passed on. The point of the proofreading and repair mechanisms is to avoid the transmission of changes. So if genes are replicators, some changes in replicators need not be passed on; those censored by the proofreading and repair mechanisms. But then we can see the production of a six-legged aphid from its eventually five-legged forebear as a triumph of the aphid's proof-reading and correction mechanism.

Nice try. Won't do. Certainly, not all genetic changes are passed on. But no gene selectionist ever said they were. The point is that some genetic changes are passed on (otherwise there could be no evolution) but *no* environmentally acquired changes are passed on (at least not with enough high fidelity to have a chance of surviving into the indefinite future). Or, if they are passed on, they are replicators by definition and that takes care of the second part of Sterelny et al.'s objection. If environmentally altered variations in patterns of cilia are inherited (as I was happy to admit in *EP*, p. 176–177) they are replicators by definition and therefore, for present purposes, honorary genes. Aphid clones are not replicators for precisely the reason that I originally gave.

Jablonka and the school of thought dubbed 'Developmental Systems Theorists' think that the complexity of embryonic development somehow detracts from the validity of the gene's eye view of Darwinism. But we must not allow complexity to become a euphemism for muddle. Gray (1992) in 'Death of the Gene: Developmental systems strike back' says:

> . . . genetic factors do not replicate themselves nor do they physically persist across generations [*of course* they don't, that is the point of Williams's 'codex', RD]. They are replicated as part of the *reproduction* of developmental systems. Remove some part of that developmental system and genetic replication may be changed or impaired. In this sense genes are no different from any other developmental interactant.

Oh yes they are. You may be sick of hearing my *leitmotif* but we are just going to have to play it one more time as a finale. It doesn't matter how complicated the developmental support structure, nor how utterly dependent DNA may be upon it, the central question remains: which elements of the Great Batesonian Nexus of development have the property that *variations* in them are replicated, with the type of fidelity that potentially carries them through an indefinitely large number of evolutionary generations? Genes certainly meet the criterion. If anything else does, let's hear it and, if the case is well made, let's by all means elect it into membership of the replicator club. But that is a separate issue. The complexity of development itself is an obscurantist red herring. Complexity is tamed by the statistics of variation. That, for heaven's sake, is why the analysis of variance was invented, and heritability is just a special case of the analysis of variance.

This should be our response to Jablonka too, and the other commentators to the extent that they invite it. We can clearly distinguish two kinds of objection to the gene's-eye-view of selection. There is the 'genes are not the only replicators' class of objection. Let's embrace that one with open arms in principle, even though we may have to bend over backwards to accommodate some pretty specious special pleading in practice. And there is the 'Dear oh dear, development is a terribly complicated nexus, isn't it?' style of objection. Don't embrace that one. Lance the boil of obfuscatory complexity with a laser scalpel. Or mutate the metaphor, and shine a laser beam of clear statistical reasoning on what really matters, which is transgenerational covariance.

Gray repeats his error with abandon. Just one more example, in case I still have failed to get the point across.

> Lots of fun could be had with these environmentalist inversions of the gene's eye view of evolution. For example, instead of the story of the selfish gene, imagine the story of the selfish oxygen. In the evolution of the earth's atmosphere oxygen was engaged in intense competition with other atmospheric gases. With the construction of green plants oxygen developed a vehicle for its efficient replication. Chlorophyll containing organisms were thus just oxygen's way of making more oxygen (Gray, loc. cit.).

I find it disturbing that anybody could be so misled as to see this as good satire, yet I have a horrible suspicion that more than one of our three

commentators would be tempted by it. If there were alternative versions of oxygen that *varied* in their talent for exploiting plants and passed on those talents to daughter oxygens, Gray would have a point. But there aren't. Oxygen is oxygen is oxygen. There is nothing there to select.

The quality of hi-fi variation is not something cheap and easy, possessed by Bateson's nests, Gray's oxygen and just about any other unit you could think of from the world of chemistry. On the contrary, it is a precious, rare, onerous, difficult talent, possessed by genes and computer viruses and a few other things – but *genuinely* few – every one of which needs rigorous defence before biologists of critical intelligence should accept it into their Darwinian models. If it were as easy as Gray jokes, the origin of life – which means the origin of self-replicated variation – would not be the major theoretical conundrum that it is.

Hi-fi variation is not some kind of arbitrary criterion, required for scripturally dogmatic reasons stemming from the teachings of Saint George Williams. It follows from first principles, the principles that tell us why any of this matters in the first place. We are interested in evolution by natural selection. In order for anything to evolve by natural selection, there has to be variation in something that is both potentially long lasting and causally powerful, so that there emerges a difference, on the evolutionary timescale, between the state of the world if one variant survives compared with the state of the world if an alternative variant survives. If neither variant survives more than a couple of generations anyway, we are not talking evolution at all. That is why hi fi variation matters and that is why Gray's oxygen joke, Bateson's nest joke and others of their kind are not funny. There may be backwards arrows in all sorts of other senses but, in the sense that specifically matters for Darwinian evolution, the causal arrow of biological development from genotype to phenotype really is a one-way arrow.

What should I say if invited to give my own 21-year retrospective on *The Extended Phenotype?* I think Laland and Jablonka are right that the gene's-eye-view – the part of the theory that I am not responsible for inventing – really has moved to the forefront of the minds of ethologists, behavioural ecologists, sociobiologists and other evolutionary biologists in the field. This is certainly gratifying. Moreover, the study of what some people call 'ultraselfish genes' or 'selfish genetic elements' has become a major growth industry.

But the part of the theory that is wholly my own, the extended phenotype itself, unfortunately cannot yet make the same claim. It lurks somewhere near the back of some biologists' minds, but not in the lobes that plan research in the field. Twenty-one years ago, I said that nobody had done a genetic study using animal artefacts as the phenotype. I think that is still true. I would admit

to disappointment, except that it invites the obvious retort: why don't you get out there and do it yourself, then? It is a fair point. I should. Maybe I will. Idleness is a poor excuse, and preoccupation with writing books only slightly better.

Meanwhile, let me conclude with an idle pipedream. It is the beautiful Indian summer of 2010, opening day of EPI, the Extended Phenotypics Institute in one of our great university cities. After the formal unveiling by a Nobel Prizewinning scientst (Royalty wasn't considered good enough), the guests are shown wonderingly around the new building. There are three wings: the Zoological Artefact Museum (ZAM), the laboratory of Parasite Extended Genetics (PEG), and the Centre for Action at a Distance (CAD).

The artefact museum is a zoological equivalent of Oxford's Pitt Rivers, which differs from other museums of human artefacts in that its specimens are grouped functionally instead of by region of origin. Instead of sections devoted to Polynesia, Africa, Asia and pre-Columbian America, the Pitt Rivers has sections devoted to fishing nets, to wind instruments, to boats, to butchering tools, to ornamental headdresses, all gathered together with their own kind regardless of their geographic provenance. EPI's museum has all the nests together, whether made by birds, insects, mammals or spiders; all the hunting nets in another case, whether made by spiders or caddis larvae; all the sexually alluring bowers in a third, and so on. Where possible, each specimen is housed next to human equivalents, and next to functionally analogous pieces of animal anatomy: lyre bird tails next to bower bird bowers, thermoregulatory heat-exchange organs next to termite mound chimneys, and so on. A central display case shows the comparative anatomy of bird nests, each one perched on its rightful branch of a phylogenetic tree: an expanded version of the tree drawn by Winkler and Sheldon (1993) for Swallows' nests.

All around the Museum are laboratories devoted to the genetics of animal artefacts. Some would say this is, strictly speaking, the genetics of their builders, but of course the ethos of EPI acknowledges no such distinction. Artefact genetics differs from conventional genetics in that the genes whose effects bear upon any one phenotype may come from different 'organisms'. Geneticists are used to handling such summations and epistatic interactions within 'organisms' under the heading of polygenes, and our extended geneticists are well versed in the mathematical theory of polygenic inheritance (Falconer 1981). Studies in the artificial selection and genetic manipulation of silkworm cocoons enjoy a generous grant from Japan, which also supports a major project on the genetics and polymer chemistry of other silk artefacts such as spider webs and caddis larva fishing nets. The artefact museum serves as the home base for field studies of the memetics of tool making and tool use in chimpanzees, sea otters, Galapagos woodpecker finches and others.

The other two wings can be imagined by analogy with the first, and by reference to Chapters 12 and 13 of *EP*. PEG is the most prosperously endowed part of the Institute, because of the medical importance of parasite genes expressing themselves in host phenotypes. As for CAD, its generous grant from agricultural funds is prompted by the hope that artificially synthesized pheromones could revolutionise pest control. But CAD's total remit embraces nothing less than the entire field of animal communication studies and, broader yet, networks of interaction in community ecology.

In all three wings, familiar phenomena are studied from an unfamiliar perspective: different angles on a Necker cube. Everyone knows that parasites manipulate their hosts. The extended geneticists of PEG differ only in that they study variations in host behaviour and morphology as phenotypes of parasite genes. Even more than their colleagues in the artefact museum, they are never far from their well-thumbed copy of Falconer's textbook, and they are as nearly as possible indifferent to their polygenes' 'organisms' of origin. The ethologists and zoosemioticists of CAD run the risk of being mistaken for Gaian eco-mystics, as they immerse themselves in the dawn chorus and call it extended embryology. But, like their colleagues in the other two wings of EPI, they pride themselves on the disciplined rigour of their theory. The motto carved over the main door of their Institute is a one-locus mutation of St Paul: "But the greatest of these is clarity."

Note

[1] I am reminded of a satirical version of Occam's Razor, which my group of Oxford graduate students mischievously attributed to a rival establishment: "Never be satisfied with a simple explanation if a more complex one is available". And that in turn reminds me to say that Laland has missed the irony in my apparent espousal of Bateson's "Great Nexus of complex causal factors interacting in development."

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The Improbability of God

by Richard Dawkins

Much of what people do is done in the name of God. Irishmen blow each other up in his name. Arabs blow themselves up in his name. Imams and ayatollahs oppress women in his name. Celibate popes and priests mess up people's sex lives in his name. Jewish *shohets* cut live animals' throats in his name. The achievements of religion in past history - bloody crusades, torturing inquisitions, mass-murdering conquistadors, culture-destroying missionaries, legally enforced resistance to each new piece of scientific truth until the last possible moment - are even more impressive. And what has it all been in aid of? I believe it is becoming increasingly clear that the answer is absolutely nothing at all. There is no reason for believing that any sort of gods exist and quite good reason for believing that they do not exist and never have. It has all been a gigantic waste of time and a waste of life. It would be a joke of cosmic proportions if it weren't so tragic.

Why do people believe in God? For most people the answer is still some version of the ancient Argument from Design. We look about us at the beauty and intricacy of the world - at the aerodynamic sweep of a swallow's wing, at the delicacy of flowers and of the butterflies that fertilize them, through a microscope at the teeming life in every drop of pond water, through a telescope at the crown of a giant redwood tree. We reflect on the electronic complexity and optical perfection of our own eyes that do the looking. If we have any imagination, these things drive us to a sense of awe and reverence. Moreover, we cannot fail to be struck by the obvious resemblance of living organs to the carefully planned designs of human engineers. The argument was most famously expressed in the watchmaker analogy of the eighteenth-century priest William Paley. Even if you didn't know what a watch was, the obviously designed character of its cogs and springs and of how they mesh together for a purpose would force you to conclude "that the watch must have had a maker: that there must have existed, at some time, and at some place or other, an artificer or artificers, who formed it for the purpose which we find it actually to answer; who comprehended its construction, and designed its use." If this is true of a comparatively simple watch, how much the more so is it true of the eye, ear, kidney, elbow joint, brain? These beautiful, complex, intricate, and obviously purpose-built structures must have had their own designer, their own watchmaker - God.

So ran Paley's argument, and it is an argument that nearly all thoughtful and sensitive people discover for themselves at some stage in their childhood. Throughout most of history it must have seemed utterly convincing, self-evidently true. And yet, as the result of one of the most astonishing intellectual revolutions in history, we now know that it is wrong, or at least superfluous. We now know that the order and apparent purposefulness of the living world has come about through an entirely different process, a process that works without the need for any designer and one that is a consequence of basically very simple laws of physics. This is the process of evolution by natural selection, discovered by Charles Darwin and, independently, by Alfred Russel Wallace.

What do all objects that look as if they must have had a designer have in common? The answer is statistical improbability. If we find a transparent pebble washed into the shape of a crude lens by the sea, we do not conclude that it must have been designed by an optician: the unaided laws of physics are capable of achieving this result; it is not too improbable to have just "happened." But if we find an elaborate compound lens, carefully corrected against spherical and chromatic aberration, coated against glare, and with "Carl Zeiss" engraved on the rim, we know that it could not have just happened by chance. If you take all the atoms of such a compound lens and throw them together at random under the jostling influence of the ordinary laws of physics in nature, it is *theoretically* possible that, by sheer luck, the atoms would just happen to fall into the pattern of a Zeiss compound lens, and even that the atoms round the rim should happen to fall in such a way that the name Carl Zeiss is etched out. But the number of other ways in which the atoms could, with equal likelihood, have fallen, is so hugely, vastly, immeasurably greater that we can completely discount the chance hypothesis. Chance is out of the question as an explanation.

This is not a circular argument, by the way. It might seem to be circular because, it could be said, *any* particular arrangement of atoms is, with hindsight, very improbable. As has been said before, when a ball lands on a particular blade of grass on the golf course, it would be foolish to exclaim: "Out of all the billions of blades of grass that it *could* have fallen on, the ball actually fell on this one. How amazingly, miraculously improbable!" The fallacy here, of course, is that the ball had to land somewhere. We can only stand amazed at the improbability of the actual event if we specify it *a priori*: for example, if a blindfolded man spins himself round on the tee, hits the ball at random, and achieves a hole in one. That would be truly amazing, because the target destination of the ball is specified in advance.

Of all the trillions of different ways of putting together the atoms of a telescope, only a minority would actually work in some useful way. Only a tiny minority would have Carl Zeiss engraved on them, or, indeed, *any* recognizable words of any human language. The same goes for the parts of a watch: of all the billions of possible ways of putting them together, only a tiny minority will tell the time or do anything useful. And of course the same goes, *a fortiori*, for the parts of a living body. Of all the trillions of trillions of ways of putting together the parts of a body, only an infinitesimal minority would live, seek food, eat, and reproduce. True, there are many different ways of being alive - at least ten million different ways if we count the number of distinct species alive today - but, however many ways there may be of being alive, it is certain that there are vastly more ways of being dead!

We can safely conclude that living bodies are billions of times too complicated - too statistically improbable - to have come into being by sheer chance. How, then, did they come into being? The answer is that chance enters into the story, but not a single, monolithic act of chance. Instead, a whole series of tiny chance steps, each one small enough to be a believable product of its predecessor, occurred one after the other in sequence. These small steps of chance are caused by genetic mutations, random changes - mistakes really - in the genetic material. They give rise to changes in the existing bodily structure. Most of these changes are deleterious and lead to death. A minority of them turn out to be slight improvements, leading to increased survival and reproduction. By this process of natural selection, those random changes that turn out to be beneficial eventually spread through the species and become the norm. The stage is now set for the next small change in the evolutionary process. After, say, a thousand of these small changes in series, each change providing the basis for the next, the end result has become, by a process of accumulation, far too complex to have come about in a single act of chance.

For instance, it is theoretically possible for an eye to spring into being, in a single lucky step, from nothing: from bare skin, let's say. It is theoretically possible in the sense that a recipe could be written out in the form of a large number of mutations. If all these mutations happened simultaneously, a complete eye could, indeed, spring from nothing. But although it is theoretically possible, it is in practice inconceivable. The quantity of luck involved is much too large. The "correct" recipe involves changes in a huge number of genes simultaneously. The correct recipe is one particular combination of changes out of trillions of equally probable combinations of chances. We can certainly rule out such a miraculous coincidence. But it *is* perfectly plausible that the modern eye could have sprung from something almost the same as the modern eye but not quite: a very slightly less elaborate eye. By the same argument, this slightly less elaborate eye sprang from a slightly less elaborate eye still, and so on. If you assume a *sufficiently large number of sufficiently small differences* between each evolutionary stage and its predecessor, you are bound to be able to derive a full, complex, working eye from bare skin. How many intermediate stages are we allowed to postulate? That depends on how much time we have to play with. Has there been enough time for eyes to evolve by little steps from nothing?

The fossils tell us that life has been evolving on Earth for more than 3,000 million years. It is almost impossible for the human mind to grasp such an immensity of time. We, naturally and mercifully, tend to see our own expected lifetime as a fairly long time, but we can't expect to live even one century. It is 2,000 years since Jesus lived, a time span long enough to blur the distinction between history and myth. Can you imagine a million such periods laid end to end? Suppose we wanted to write the whole history on a single long scroll. If we crammed all of Common Era history into one metre of scroll, how long would the pre-Common Era part of the scroll, back to the start of evolution, be? The answer is that the pre-Common Era part of the scroll would stretch from Milan to Moscow. Think of the implications of this for the quantity of evolutionary change that can be accommodated. All the domestic breeds of dogs - Pekingeses, poodles, spaniels, Saint Bernards, and Chihuahuas - have come from wolves in a time span measured in hundreds or at the most thousands of years: no more than two meters along the road from Milan to Moscow. Think of the quantity of change involved in going from a wolf to a Pekingese; now multiply that quantity of change by a million. When you look at it like that, it becomes easy to believe that an eye could have evolved from no eye by small degrees.

It remains necessary to satisfy ourselves that every one of the intermediates on the evolutionary route, say from bare skin to a modern eye, would have been favored by natural selection; would have been an improvement over its predecessor in the sequence or at least would have survived. It is no good proving to ourselves that there is theoretically a chain of almost perceptibly different intermediates leading to an eye if many of those intermediates would have died. It is sometimes argued that the parts of an eye have to be all there together or the eye won't work at all. Half an eye, the argument runs, is no better than no eye at all. You can't fly with half a wing; you can't hear with half an ear. Therefore there can't have been a series of step-by-step intermediates leading up to a modern eye, wing, or ear.

This type of argument is so naive that one can only wonder at the subconscious motives for wanting to believe it. It is obviously not true that half an eye is useless. Cataract sufferers who have had their lenses surgically removed cannot see very well without glasses, but they are still much better off than people with no eyes at all. Without a lens you can't focus a detailed image, but you can avoid bumping into obstacles and you could detect the looming shadow of a predator.

As for the argument that you can't fly with only half a wing, it is disproved by large numbers of very successful gliding animals, including mammals of many different kinds, lizards, frogs, snakes, and squids. Many different kinds of tree-dwelling animals have flaps of skin between their joints that really are fractional wings. If you fall out of a tree, any skin flap or flattening of the body that increases your surface area can save your life. And, however small or large your flaps may be, there must always be a critical height such that, if you fall from a tree of that height, your life would have been saved by just a little bit more surface area. Then, when your descendants have evolved that extra surface area, their lives would be saved by just a bit more still if they fell from trees of a slightly greater height. And so on by insensibly graded steps until, hundreds of generations later, we arrive at full wings.

Eyes and wings cannot spring into existence in a single step. That would be like having the almost infinite luck to hit upon the combination number that opens a large bank vault. But if you spun the dials of the lock at random, and every time you got a little bit closer to the lucky number the vault door creaked open another chink, you would soon have the door open! Essentially, that is the secret of how evolution by natural selection achieves what once seemed impossible. Things that cannot plausibly be derived from very different predecessors *can* plausibly be derived from only slightly different predecessors. Provided only that there is a sufficiently long series of such slightly different predecessors, you can derive anything from anything else.

Evolution, then, is theoretically *capable* of doing the job that, once upon a time, seemed to be the prerogative of God. But is there any evidence that evolution actually has happened? The answer is yes; the evidence is overwhelming. Millions of fossils are found in exactly the places and at exactly the depths that we should expect if evolution had happened. Not a single fossil has ever been found in any place where the evolution theory would not have expected it, although this *could* very easily have happened: a fossil mammal in rocks so old that fishes have not yet arrived, for instance, would be enough to disprove the evolution theory.

The patterns of distribution of living animals and plants on the continents and islands of the world is exactly what would be expected if they had evolved from common ancestors by slow, gradual degrees. The patterns of resemblance among animals and plants is exactly what we should expect if some were close cousins, and others more distant cousins to each other. The fact that the genetic code is the same in all living creatures overwhelmingly suggests that all are descended from one single ancestor. The evidence for evolution is so compelling that the only way to save the creation theory is to assume that God deliberately planted enormous quantities of evidence to make it *look* as if evolution had happened. In other words, the fossils, the geographical distribution of animals, and so on, are all one gigantic confidence trick. Does anybody want to worship a God capable of such trickery? It is surely far more reverent, as well as more scientifically sensible, to take the evidence at face value. All living creatures are cousins of one another, descended from one remote ancestor that lived more than 3,000 million years ago.

The Argument from Design, then, has been destroyed as a reason for believing in a God. Are there any other arguments? Some people believe in God because of what appears to them to be an inner revelation. Such revelations are not always edifying but they undoubtedly feel real to the individual concerned. Many inhabitants of lunatic asylums have an unshakable inner faith that they are Napoleon or, indeed, God himself. There is no doubting the power of such convictions for those that have them, but this is no reason for the rest of us to believe them. Indeed, since such beliefs are mutually contradictory, we can't believe them all.

There is a little more that needs to be said. Evolution by natural selection explains a lot, but it couldn't start from nothing. It couldn't have started until there was some kind of rudimentary reproduction and heredity. Modern heredity is based on the DNA code, which is itself too complicated to have sprung spontaneously into being by a single act of chance. This seems to mean that there must have been some earlier hereditary system, now disappeared, which was simple enough to have arisen by chance and the laws of chemistry and which provided the medium in which a primitive form of cumulative natural selection could get started. DNA was a later product of this earlier cumulative selection. Before this original kind of natural selection, there was a period when complex chemical compounds were built up from simpler ones and before that a period when the chemical elements were built up from simpler elements, following the well-understood laws of physics. Before that, everything was ultimately built up from pure hydrogen in the immediate aftermath of the big bang, which initiated the universe.

There is a temptation to argue that, although God may not be needed to explain the evolution of complex order once the universe, with its fundamental laws of physics, had begun, we do need a God to explain the origin of all things. This idea doesn't leave God with very much to do: just set off the big bang, then sit back and wait for everything to happen. The physical chemist Peter Atkins, in his beautifully written book *The Creation,* postulates a lazy God who strove to do as little as possible in order to initiate everything. Atkins explains how each step in the history of the universe followed, by simple physical law, from its predecessor. He thus pares down the amount of work that the lazy creator would need to do and eventually concludes that he would in fact have needed to do nothing at all!

The details of the early phase of the universe belong to the realm of physics, whereas I am a biologist, more concerned with the later phases of the evolution of complexity. For me, the important point is that, even if the physicist needs to postulate an irreducible minimum that had to be present in the beginning, in order for the universe to get started, that irreducible minimum is certainly extremely simple.

By definition, explanations that build on simple premises are more plausible and more satisfying than explanations that have to postulate complex and statistically improbable beginnings.

And you can't get much more complex than an Almighty God!

THE ENVIRONMENT FOUNDATION

THE VALUES PLATFORM FOR SUSTAINABILITY

INAUGURAL LECTURE

Wednesday, 14 November 2001, at the Royal Institution
with Sir Geoffrey Chandler, CBE, Trustee, the Environment Foundation, in the Chair

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Sustainability doesn't come naturally: a Darwinian Perspective on Values

Sir Geoffrey Chandler

The Environment Foundation is a small charity, which has been working quietly with others to put sustainability on the business agenda. We are now taking a major step forward in developing a five year programme, examining the values that will be necessary if we are to have a sustainable world. It will bring together people from different sectors of society and different generations, and with differing views, to probe and question and identify those values. It is a particular pleasure that so many are with us tonight representing so broad a spectrum of the world in which we live – from education, research, business, government, non governmental organisations and the media. Indeed we have teenagers present and at least one highly distinguished nonagenarian.

This occasion is intended as the point of departure for the Foundation's new programme. It is a programme which tackles one of the most fundamental problems of our time – the conflict between the values we hold and the manner in which we behave and, where business is concerned, the conflict between values and financial wealth creation. We believe that action in pursuit of sustainability must essentially address values and attitudes, not simply technology and legislation. We live in a world of our own making, but it is a world that we cannot much like. It suffers from social inequity, economic inequality and accelerating degradation of the physical environment and is manifestly unsustainable, which is why sustainability is now at the top of the agenda. But is what we have our inescapable inheritance? Was the 17th century poet, Fulke Greville, correct when he wrote 'Oh miserable condition of humanity, Born under one law, to another bound'? Are we stuck with what we have got or do we in fact have a choice?

We could have no more appropriate speaker this evening to help us begin to answer those questions than the evolutionary biologist, Professor Richard Dawkins. He is the first holder of the Charles Simonyi Professorship of the Public Understanding of Science at the University of Oxford, but perhaps is more widely known for his books, such as *The Selfish Gene* and *The Blind Watchmaker,* and as one of the most challenging intellects of our time.

Professor Richard Dawkins

"What comes naturally" is a topic which Darwinism might be expected to illuminate. Darwinian natural selection gives us just about everything else in our nature – our bones, our organs, our instincts. If there is a reason to exclude our *values*, it had better be a good one. The values of sustainability are important to all of us here and I enthusiastically include myself. We therefore might hope that these too are built into us by natural selection. I shall tell you today that this is not so. On the contrary, there is something profoundly anti-Darwinian about the very idea of sustainability. But this is not as pessimistic as it sounds. Although we are products of Darwinism, we are not slaves to it. Using the large brains that Darwinian natural selection has given us, it is possible to fashion new values that contradict Darwinian values and that is the policy that I shall urge upon you.

Our starting point must be the fundamental logic of Darwinism itself. Simply stated, everybody has ancestors but not everybody has descendants. We have all inherited genes for being good at becoming an ancestor. Ancestry is the ultimate Darwinian value. In a purely Darwinian world, all other values are subsidiary and, synonymously, gene survival is the ultimate Darwinian value. So, as a first expectation, all animals and plants can be expected to work ceaselessly for the long-term survival of the genes that ride inside them. The world is divided into those for whom the simple logic of this is as clear as daylight and those who, no matter how many times it is explained to them, just don't get it.

Alfred Russell Wallace put the problem in a letter to his co-discoverer of natural selection, "My dear Darwin, I have been so repeatedly struck by the utter inability of numbers of intelligent persons to see clearly, or at all, the self-acting and necessary effects of natural selection". Those who don't get it either assume that there must be some kind of personal agent in the background to do natural selection's choosing; or they wonder why individuals should value the survival of their own genes, rather than, for instance, the survival of their species, or the survival of the ecosystem of which they are a part. After all, say the second group of people, if the species or the ecosystem don't survive, nor will the individual. So it must be in their interest to value the species and the ecosystem. As we shall see, this is faulty reasoning. If only it were true, the values of sustainability would simply be built into us by natural selection. What an appealing thought that would be.

Who decides, then, that gene survival is the ultimate value? Nobody decides, and there is no personal agent doing the choosing. It all just follows automatically from the fact that genes reside in the bodies that they build and are the only things (in the form of coded copies) that reliably persist down the generations. This is the modern version of the point Wallace was making with his apt phrase 'self-acting'. Individuals are not miraculously nor cognitively inspired with values and goals that will guide them in the paths of gene survival. Only the past can have an influence, not the future. Animals behave as if striving for the future values of the genes simply and solely because they bear and are influenced by genes that survived through ancestral generations in the past. Those ancestors that, in their own time, behaved as if they valued whatever was conducive to the future survival of their genes, have bequeathed those very genes to their descendants. So their descendants behave as if they, in their turn, value the future survival of their genes. It is an entirely unpremeditated, self-acting process, which works as long as future conditions are tolerably similar to past conditions. If they are not, the result is often extinction of the species. But it is not differential species extinction itself which constitutes the process of natural selection. If you understand that, then you understand Darwinism in my view. The word Darwinism, by the way, was coined by the ever-generous Wallace.

I am going to continue my Darwinian analysis of values using bones as my example for the moment because they are unlikely to ruffle political or other human hackles. It is not that I mind ruffling hackles per se but, in this case, it would be a distraction and I do mind distractions that get in the way of clarity.

Bones are not perfect. They sometimes break. A wild animal that breaks its leg is unlikely to survive in the harsh competitive world of nature. It will be vulnerable to predators, unable to catch prey, whatever it might be. So, why doesn't natural selection thicken bones so that they never break? We humans, by artificial selection, could breed a race of dogs whose leg bones were so stout that they literally never broke. So why doesn't nature do the same? The answer of course is costs – economic costs – and this implies a system of Darwinian values.

Engineers and architects are never asked to build unbreakable structures, impregnable walls, bridges that can't fall down, trains that can't come off the rails. Instead, the engineer is given a monetary budget and asked to do the best he can according to certain criteria within that constraint. Or he may be told the bridge must bear a weight of some number of tons and must withstand gales three times more forceful than the worst ever recorded in this area. Now go ahead and design the cheapest bridge you can that meets these specifications. Safety factors in engineering imply that we put a monetary value on human life. If we don't like that, that's tough – there's no other way.

Designers of civil airliners are more risk-averse than designers of military aircraft. All aircraft and ground control facilities could be made safer if more money was spent More redundancy could be built into control systems. The number of flying hours demanded of pilots could be increased, and so on. Recent events may make us wish that safety checks on aircraft and security checks on passengers were more stringent and time-consuming, and they have recently become so. The balance has shifted slightly, but there will always be cost constraints on how stringent they can become. We are prepared to pay a lot of money for human safety, but not infinite amounts. Like it or not, we are forced to put monetary value on human life. People who think it somehow wicked to talk about putting monetary value on human life, people who emotionally declare that a single human life has infinite value, are living in cloud cuckoo land.

Darwinian selection, too, optimises within economic limits and can be said to have values in the same sense. My colleague Nicholas Humphrey, continues this argument with another analogy from engineering. Henry Ford, it is said, commissioned a survey of the scrap yards of America to find out if there were parts of the Model T which never failed. His inspectors came back with reports of almost every kind of breakdown – axles, brakes, pistons – all were liable to go wrong. But they drew attention to one notable exception – the king pins of the scrapped cars invariably had years of life left in them. With ruthless logic, Ford concluded that the king pins on the Model T were too good for their job and ordered that, in future, they should be made to an inferior specification. Nature, Humphrey concludes, is surely at least as careful an economist as Henry Ford. Humphrey applied his lesson to the evolution of intelligence, but we can apply it to bones or anything else.

Imagine that we commissioned a survey of the corpses of gibbons, and looked to see whether there are any bones that never break. Suppose we found that every bone in the body breaks at some time or another, with one exception – let's say it's the thigh bone, the femur, which has never been known to break? Henry Ford would be in no doubt – in future, the femur must be made to an inferior specification – and natural selection would agree. Individuals with slightly thinner femurs, who have diverted the material saved into some other purpose, say building up other bones, would survive, or at least reproduce, more successfully. In a machine or an animal, the simplified ideal is that all the parts should wear out simultaneously. If there is one part that consistently has years of life left in it after the others have worn out, then it is over-designed. Material that went into building it should instead have been diverted to other parts. If there is one part that consistently wears out before everything else, then it is under-designed and should be reinforced, using materials taken away from the over-designed parts. Natural selection will tend to uphold an equilibration rule – rob from strong bones to pay weak ones until all are of equal strength.

I said that that's an over simplification, the reason being that not all the bits of an animal or a machine are equally important. That's why in-flight entertainment systems in airliners go wrong, thankfully, more often than rudders or jet engines. A gibbon, unlike a human, might be able to afford a broken leg better than a broken arm, because its way of life depends on its swinging through the trees. So a gibbon with a broken leg might just survive to have another child, whilst a gibbon with a broken arm probably wouldn't. So the equilibration rule I mentioned has to be tempered – rob from strong bones to pay weak ones, until you have equalised the risks to your survival accruing from breakages in all parts of your skeleton.

But who is the 'you' that we are talking about in giving these instructions? Obviously it is not an individual gibbon. The 'you' is an abstraction. You can think of it as a lineage of gibbons in ancestor-descendant relation to one another, represented by the genes that they share. As the lineage progresses, ancestors whose genes make the right adjustments survive to leave descendants who inherit those correctly equilibrated genes. The genes that we see in the world tend to be the ones that get the balance right, because they have survived through a long line of successful ancestors, who have not suffered the breakage of under-designed bones, nor the waste of over-designed bones.

So much for bones. Now values. We need to establish in Darwinian terms what values are doing for living things. Where bones stiffen limbs, what do values do for their possessors? Having established that the ultimate Darwinian value is gene survival, we are now going to mean something closer to what humans ordinarily mean by values. By values I am going to mean the criteria in the brain by which animals choose how to behave. What are the proximal values in the brain for which animals can be expected to strive, given that the ultimate value is gene survival?

The majority of things in the universe don't actively strive for anything. They just are. I am concerned with the minority that do strive for things, and this minority I shall call value-driven. Some of them are animals and plants, and some are man-made machines – thermostats, heat-seeking missiles. Numerous physiological systems in animals and plants are controlled by negative feedback. There is a target value which is defined in the system. Discrepancies from the target value are sensed and fed back into the system, causing it to change its state in the direction of reducing the discrepancy, until the discrepancy becomes ideally zero. Other value-seeking systems improve with experience. From the point of view of defining values in learning systems, the key concept is reinforcement. Reinforcers are either positive, in which case we call them rewards, or negative punishments. Rewards are states of the world which, when encountered, cause an animal to repeat whatever it recently did; and punishments are the opposite: states of the world which, when encountered, cause an animal to avoid repeating whatever it recently did. The stimuli that animals treat as rewards and punishments are primitive *values*.

Psychologists make a further distinction in primary and secondary reinforcers. Chimpanzees, for example, can learn to work for food as a primary reward, but they will also learn to work for the equivalent of money, which they can then put into slot machines to get food. Some scientists, such as Konrad Lorenz, the grand old man of ethology, have argued that Darwinian natural selection has built in specific rewarding mechanisms, specified differently and in detail for each species to fit its unique way of life. Lorenz believed, for instance, that squirrels had an appetite not just for food, but an appetite to perform the motor patterns of getting food – of cracking nuts in this case – quite independently of the desire to eat them. He would have said that, for a beaver, the act of building a dam has a rewarding value in itself. The nervous system is pre-equipped with the *value* of liking building dams.

Perhaps the most elaborately surprising examples of primary values of this kind come from bird song. Different species of bird develop their songs in different ways, of course. The American Song Sparrow is a fascinating mixture. Young Song Sparrows brought up completely alone end up singing normal Song Sparrow song. So unlike, say Bullfinches, they don't learn by imitation of other birds, but they do learn. Young Song Sparrows teach themselves to sing by babbling at random and repeating those fragments that sound as a Song Sparrow song ought to sound. There is a template built in of Song Sparrow song genetically specified. You could say that the information of what a Song Sparrow song sounds like is built in by the genes, but note that it is not built in on the motor side. It is not built in as a set of instructions, "Sing like this". It is built in on the sensory side. The instructions are, "Sing at random, until you hear a fragment that sounds like this and then repeat that fragment". So it's like the rat in the skinner box but, unlike the rat, this reward is highly elaborate and highly specific.

It is examples like this that stimulated Lorenz to use the colourful phrase 'innate schoolmarm', or innate teaching mechanism, in his various lengthy attempts to resolve the ancient dispute over nativism versus environmentalism. His point was that, however important learning is, there has to be innate guidance of what to learn. In particular, each species needs to be supplied with its own specifications, its own values, specifying what to treat as rewarding and what punishing. "Primary values", Lorenz was saying, "have to come ultimately from Darwinian natural selection". It should follow that, given enough time, we should be able to breed changed values, by artificial selection of the kind we used to breed, say, bulldogs from wolves. We should be able to breed a race of animals that enjoy pain and hate pleasure. Of course, by the animals' newly evolved definition, this statement is an oxymoron and I have to re-phrase it – by artificial selection, we could reverse the previous definitions of pleasure and pain. The animals so modified would be, of course, less well equipped to survive in the wild than their wild ancestors, just as bulldogs incidentally are for many other reasons. Bulldog puppies can't be born – they need a caesarean section.

Wild ancestors have been naturally selected to enjoy those stimuli most likely to improve their survival. They have been naturally selected to have the right values, the right proximal values to promote their ultimate value of gene survival and, of course, to treat as painful those stimuli most likely to injure them and prevent their surviving. So injury to the body – puncturing the skin, breaking bones – are all perceived as painful, not for arbitrary reasons, but for good Darwinian reasons. Our artificially selected animals in this hypothetical experiment will enjoy having their skin pierced, will actively seek to break their own bones and will bask in a temperature so hot or so cold as to endanger their survival. And similar artificial selection, I venture, would work with humans. Not only could you breed humans with changed tastes, changed primary values, but you could breed for all sorts of things like callousness, sympathy, loyalty, slothfulness, petty meanness or the protestant work ethic. This is a less radical claim then it sounds, because genes don't fix behaviour deterministically. They only contribute quantitatively to statistical tendencies, which are already influenced by many other things. Nor does it imply a single gene for each of these complicated things, any more than the feasibility of breeding race horses implies a single gene for speed. In the absence of artificial breeding, our own values are presumably influenced by natural selection under conditions that prevailed in the Pleistocene of Africa and before.

Humans are unique in many ways and perhaps the most obviously unique feature is language. Whereas eyes have evolved between 40 and 60 times independently around the animal kingdom, language, as far as we know, has evolved only once. Superficially, language seems to be purely learned, but there is strong genetic supervision of the learning process. The particular language we speak is of course learned, but the tendency to learn language, rather than just any old thing, is inherited and evolved specifically in our human line. We inherit evolved rules for grammar. The exact readout of these rules varies from language to language, but their deep structure is laid down by the genes and presumably evolved by natural selection, just like our bones.

Evidence is good that the brain contains a language module, a computational mechanism that actively seeks to learn language, and actively uses grammatical rules to structure it. According to the young and thriving discipline of evolutionary psychology, the language learning module is just an example of a whole set of inherited special-purpose computational modules in the brain – perhaps modules for sex and reproduction; for analysing kinship, which is important for doling out altruism and avoiding incest; for counting debts and policing obligations; for judging fairness and natural justice; perhaps for throwing projectiles accurately towards a target; and for classifying animals and plants. These modules will presumably be mediated by specific built-in values.

If we turn our Darwinian eyes on our modern civilised selves and our predilections – our aesthetic values, our capacity for pleasure, our arts, our philosophies – it is important to wear sophisticated spectacles. Don't ask how a middle manager's ambitions for a bigger desk and a softer office carpet benefit his selfish genes. Ask instead how these urban partialities might stem from a mental module which was selected to do something else in a very different place and time. For office carpet perhaps (and I really mean perhaps) read soft and warm animal skins whose possession betokened hunting success.

A little parable here. We might, on seeing moths flying into candle flames ask, "What is the Darwinian survival value for moths of making burnt offerings of themselves in candle flames?" My point will be that that's the wrong question to ask. Instead we should be asking, "What's the survival value of the kind of nervous mechanism which, when there are candles about, has the effect of guiding moths into them?" A possible solution is this. Lots of insects use rays from distant celestial objects as a compass. You can see why this works because the rays from, say, the moon, the stars, or the sun, are hitting us from infinity. They are therefore parallel, and the rule of thumb in the nervous system that maintains a fixed angle relative to these rays will work, and cause the animal to maintain a fixed compass direction. That presupposes that the object is a celestial object, or at least is at optical infinity. A candle is not at optical infinity. The rays radiate out from a central point and, if you follow that same rule of thumb while maintaining an acute angle to the rays, you will describe a neat logarithmic spiral into the candle flame. So the right way to express the story of the moth and the candle flame is not to ask why they kill themselves, but to ask why they maintain a fixed angle relative to light rays. If you put it like that, and think your way back to a time before candles were invented; before artificial close sources of light at night were invented; back to where any source of light had to be at optical infinity, then you will get the right answer. That's the kind of thing we have to do when asking questions about the evolution of human values.

Why do men want to be rich and powerful? Remember the parable of the moth and the candle. In our society wealth tends, on the whole, not to be translated into genetic success. We have to think our way back to a time when society might have been more like the West African pop singer who has been married 80 times and is married to his entire backing group. In our society wealth more usually buys things like Rolls Royces, although occasionally it can buy what it primitively used to, which would have been a harem and therefore reproductive success. It's just another illustration of the parable of the moth and the candle.

Evolutionary psychologists have coined the term environment of evolutionary adaptedness, or EEA, for the set of conditions in which our wild ancestors evolved. There is a lot we do not know about the EEA. The fossil records are limited and some of what we guess about it comes from a kind of reverse engineering, from examining ourselves and trying to work out the sort of environment to which our attributes would have been well adapted. We know from fossil evidence that the EEA was located in Africa, probably but not certainly scrubby savannah land. It is plausible that our ancestors lived in these conditions as hunter gatherers, perhaps in something like the way modern hunter gatherer tribes live but, at least in earlier periods, with a less developed technology. We know that fire was tamed more than a million years ago by *Homo erectus.* We know various other things, but not a great deal. Whenever the exodus from Africa happened, and that is controversial, there has evidently been time for humans to adapt to local conditions. Arctic humans are very different from tropical ones, physically as well as culturally. There has been time for biochemistries to diverge in response to diet. Some peoples, perhaps those with herding traditions, retain into adulthood the ability to digest lactose, a sugar found in milk. In other peoples, only children can digest milk, and the adults suffer from an unpleasant condition – lactose intolerance. Presumably such differences have evolved by natural selection quite rapidly in different cultural environments. If natural selection has had time to shape our bodies and our biochemistries since some of us left Africa, it should also have had time to shape our brains and our values over the rather longer time that we consider our ancestors to have lived in the EEA.

Various researchers, notably Gordon Orians of the University of Washington, have been round the world on rather a cushy research assignment, looking at gardens – at what sort of gardens people like – to test the hypothesis that there is some sort of innate specification of the kind of world we like to live in, which is reflected in the gardens we cultivate. Is it something like the EEA? You might guess that an important virtue of a site for our ancestors to live in might have been the presence of water. Maybe this is why everybody loves a stream or pond in their garden, and why so many of us claim to be lulled to sleep by the reassuring sound of running water. There have been studies in which children have been asked to judge which kind of landscape they find most attractive, and Orians at least claimed that very young children are most drawn to East African savannah. I must say that I am a little bit sceptical of the inferences drawn from this, but you can see that it is an interesting kind of approach.

Fear of heights, which is not shown by steeplejacks building skyscrapers in New York, is shown by virtually all of the rest of us. Vertigo and the common dreams of falling might well be natural in species that spend a good deal of their time up trees, as our ancestors did. Fear of snakes and spiders and scorpions might, with benefit, be built into any African species. If you have a nightmare about snakes, it is just possible that you are actually dreaming about snakes, rather than symbolic phalluses. Biologists have often noted that phobias against snakes and scorpions and heights are a lot more common than phobias against electric light sockets, motor cars and guns. Yet, in our temperate and urban world, snakes and spiders on the whole no longer constitute a source of ever-present danger, whereas electric sockets, guns and cars are potentially lethal.

It is notoriously hard to persuade drivers to slow down in a fog, or refrain from tailgating at high speed. The economist Armen Alchian has ingeniously suggested that we should abolish seat belts and instead compulsorily fix a sharp spear to all cars in the middle of the steering wheel, pointing straight at the driver's heart. I think I would find it persuasive, whether or not for atavistic reasons. I also find intellectually persuasive the following calculation: if a car travelling at 80 miles per hour is abruptly slammed to a complete halt, this is equivalent to hitting the ground after falling from a New York skyscraper. In other words, when you are driving fast, it's exactly as if you were hanging from the top of the Empire State Building by a rope, sufficiently thin that its probability of breaking is equal to the probability that the driver in front of you will do something really stupid. I know almost nobody who could happily sit on a window sill up a skyscraper, and very few who do things like bungy jumping willingly. Yet almost everybody happily drives at high speed along motorways, even when they clearly understand in a cerebral way that the dangers are precisely equivalent. I think it quite plausible that we are genetically programmed to be afraid of heights, but not to be afraid of travelling at high speeds horizontally in wheeled vehicles, because our ancestors would never have met them.

Continuing our guesswork about our ancestors' world – the EEA – there is reason to think that we lived in stable bands, either roving and foraging like modern baboons or, perhaps, more settled in villages like present day hunter gatherers, such as the Yanomami of the Amazon jungle. In either of these cases, stability of grouping in villages or roving bands means that individuals would tend to encounter the same other individuals repeatedly through their lives. Seen through Darwinian eyes, this could have had important consequences for the evolution of our values. In particular it might help us to understand why, from the point of view of our genes, we are so absurdly nice to each other and I shall be referring back to that in a moment.

I now finally want to come to sustainability itself and the values that might encourage it. From a Darwinian point of view, the problem with sustainability is this: sustainability is all about long-term benefits of the world or of the ecosystem at the expense of short-term benefits. Darwinism encourages precisely the opposite values. Short-term genetic benefit is all that matters in a Darwinian world. Superficially, the values that will have been built into us will have been short-term values not long-term ones.

People of goodwill such as, I suspect, everybody in this room, are rightly preoccupied with sustainability, with renewable resources, with taking the side of the future against short-term private gain. Not surprisingly, the rhetoric of such people tends to place nature on a pedestal, where every prospect pleases and only man is vile. For reasons we have just seen, alas, it is not like that, quite the contrary. But as I said at the outset, this is not a reason for despair, nor does it mean that we should cynically abandon the long-term future, gleefully scrap the Kyoto Accords and similar agreements, and get our noses down in the trough of short-term greed. What it does mean is that we must work all the harder for the long-term future, in spite of getting no help from nature, precisely because nature is not on our side.

There is a confusion here with another strand of rhetoric – that of the noble savage. Tribal, so-called primitive, peoples have been thought to be in tune with nature, conserving stocks for the future, taking only what they need, living in harmony with the land, respecting their prey even as they kill them. This rhetoric falls foul of the facts. Unfashionable though it may be to say so, it is looking more and more likely, for example, that the magnificent Pleistocene megafauna of North America died out as a direct consequence of the arrival, perhaps some 13,000 years ago, of hunter gatherers, who had walked across what was then the Bering land bridge. Primitive agriculture too tends to be of the slash and burn variety, which is the very opposite of sustainable, the very opposite of forward-looking.

Humans are no worse than the rest of the animal kingdom. We are no more selfish than any other animals, just rather more effective in our selfishness and therefore more devastating. All animals do what natural selection programmed their ancestors to do, which is to look after the short-term interest of themselves and their close family, cronies and allies. If any species in the history of life has the possibility of breaking away from short-term Darwinian selfishness and of planning for the distant future, it is our species. We are earth's last best hope, even if we are simultaneously the species most capable in practice of destroying life on the planet. When it comes to taking the long view we are literally unique. No other species is remotely capable of it. If we do not plan for the future, no other species will.

In the 1950s when it was becoming fashionable to worry about over-population and pollution, ecologists talked about prudent predators. Human fisheries, whale fisheries and so on, would ideally protect future stocks by banning, say, small-mesh nets. Wholesale slaughter of whales, at least theoretically, was supposed to be replaced by carefully managed cropping. Those 1950's ecologists thought that wild predators were equally prudent conservationists. They thought wild predators didn't over-hunt their prey. They called them 'prudent predators.' Nobody was suggesting that these prudent predators were consciously or deliberately foresightful, in the way that human conservationists are, or can be. So it had to be done by some kind of natural selection, and the name 'group selection' was used. Those groups or species whose individuals single-mindedly pursued prey stocks to extinction would themselves go extinct. The world would be left with those groups or species whose individuals behaved, albeit unconsciously, in a prudent, conservationist, far sighted, sustainable way. It is a pity, and I wish it were otherwise, but group selection models don't work. Differential group survival obviously happens, in the trivial sense that some groups go extinct and others survive, but there is no evidence that any form of group selection drives evolution. Group selection is based on no coherent theory. The only coherent theory of adaptation we have is the neo-Darwinian theory of differential survival of replicators, usually genes in gene pools. Any other kind of Darwinism, if it is to work at all, must substitute a true replicator for the gene. The 'meme', for example, has been suggested as the cultural analogue of the gene. There could, at least in theory be a meme-based version of Darwinism. Memes, like genes, are true replicators. But I shall say no more about memes today. Groups and species are not replicators.

To see why the idea of prudent predators is theoretically unsound, imagine that a race of prudent predators somehow managed to come into existence. Each individual in the population restrains itself from over-hunting the food supply. It sacrifices its own short-term gain in the interests of a sustainable long-term supply for the species. Now imagine what will happen if a single mutant arises who ignores long-term sustainability and instead goes all out for short-term gain. Whose genes will spread through the population – the genes of the selfish exploiter or the genes of a typical member of the prudent majority? You can see the answer, and mathematical models confirm it. The majority will soon cease to be a majority. In the jargon of our subject, prudent predator is not an evolutionarily stable strategy.

I suppose I should mention here that there is a workable modern theory which calls itself group selection, but it isn't true group selection at all. It is something very different, masquerading under the name group selection. The so-called 'new' group selection is a hamfisted way of re-expressing the well established Darwinian theories of kin selection and reciprocation, which we have had for a long time. We have long understood that natural selection can favour genes that make individuals look after their close kin, who statistically share the same genes, or will look after unrelated individuals with whom they can build up relationships of mutual back scratching. That is not group selection, and it certainly does not provide a satisfactory theory of prudent predators.

There is a tension between short-term individual welfare and long term group welfare or world welfare. If it were left to Darwinism alone there would be no hope. Short-term greed is bound to win. The only hope lies in the unique human capacity to use our big brains with our massive communal database and our forward simulating imaginations. This is what the Kyoto Accords and similar initiatives are all about. To a Darwinist it is not surprising that it is so hard to get agreement in support. It is not good enough, of course, to just write down a prescription for the future of the world as though we were a benevolent dictator, with the power to make things happen. Alas, we are not a benevolent dictator, and even dictators who start off benevolent seldom remain so. We seem to be stuck with some sort of democracy and we had better make the most of it.

To resolve the tension between short-term and long-term interests is hard. How do you get people – millions and millions of mostly nice (but not overwhelmingly nice), people, somewhat altruistic (but not very altruistic), people – to agree to forgo some of their own short-term gains and do something about the long-term future of the world? As a leader, assuming you do not have dictatorial powers, how do you persuade people and still get elected next time around? Two connected theoretical frameworks are often invoked, known as 'The Tragedy of the Commons' and 'The Prisoner's Dilemma', from which lessons can be drawn. I haven't time to explain these, so must hope that they are sufficiently well known under these names.

The optimal, or more strictly called evolutionarily stable or collectively stable, individual strategies for prospering in a many person Prisoner's Dilemma game have been much studied. Under some conditions a limited form of altruism can prosper in a fundamentally selfish world. It is also interesting to think of mega-strategies that a government might employ for engineering the rules of the game in the right direction – engineering the game in such a way that individual players are more likely to prosper from their own forward looking altruism.

Taxes are a good example. Nobody likes paying taxes, but most of us recognise them as necessary. We pay them as a necessary evil – a tithe on our own short-term selfish gains in the interests of society as a whole, and, we hope the long-term future. Even if we have no children we recognise, as a purely Darwinian machine would not, the long-term desirability of educating the children of our society. We want to live in a nation that educates its young and cares for its old, so we pay our taxes even though we may grumble as we do so. What we find much harder – I speak for myself, but I have never heard anyone dissent – is the thought that we are paying our taxes and somebody else is not. We are deeply indignant at what we perceive as unfairness. I think this sensitivity to unfairness is probably another of the fundamental values built into us primitively. Most of us do not too much mind giving up some selfish benefit for the future benefit of the community, so long as we can be reassured that the system is fair and is being properly enforced, so that others are not getting away with failing to play their part.

The same is true of the Tragedy of the Commons. All the cattle owners know that if too many cattle are placed on the common land, overgrazing will lead to erosion and starvation. All individuals can see that it would be better if they all showed restraint, and rationed their use of the common land. The Tragedy of the Commons is that the benefit of cheating accrues to the individual who does the cheating and him alone, but the cost of cheating is borne by everybody equally, not just the cheat but everybody else too. So, in a world of voluntary restraint and no policing, cheating unfortunately makes sense. If you rely on voluntary rationing somebody will break the convention and in this case put too many cattle out on the common. What honest participants in the tragedy of their commons crave is strong policing to punish cheats. The only alternative is fencing. Divide the land up, so that each individual farmer has his own small plot and that way the costs of overgrazing are borne by the individual overgrazer just as exclusively as the benefits of grazing. This is ultimately why the majority of farmland is fenced and it is, incidentally, why territoriality is so common in the animal kingdom as well. It is the tragedy of the sea and of the atmosphere that they cannot be fenced in this way. So whales are hunted to extinction. Greenhouse gases are spewed out, to the immediate benefit of the industries doing the spewing, but the costs are shared equally by everybody.

I began by saying that Darwinism was not friendly to the values of sustainability. To the extent that our values stem from the Darwinian selection of our ancestors, this sounds like a pessimistic conclusion. The only solution to the problem of sustainability is long-term foresight, and long-term foresight is something that Darwinian natural selection does not have. I have said that hope lies in a uniquely human capacity for foresight. But how, you might ask, do we manage to have foresight given that we ourselves are products of Darwinian natural selection, which favours only short-term gain? Some people have even complained at what they see as an inconsistency in my position. How can I on the one hand say that we are the products of Darwinian selection of selfish genes, which is incorrigibly shortsighted, yet at the same time say that salvation lies in humanity's capacity for looking far ahead?

The answer lies in the fact that brains, although they are the products of natural selection, follow their own rules, which are different from the rules of natural selection. This is obvious in the case, for example, of contraception. Contraception is clearly anti-Darwinian. It would be hard to imagine anything more anti-Darwinian than contraception. Yet we do it. The brain is big enough to over-ride the genes in this case. The brain exists originally as a device to aid gene survival. The ultimate rationale for the brain's existence, and for its large size in our own species, is like everything else in the natural world, gene survival. As part of this, the brain has been equipped by the natural selection of genes with the power to take its own decisions – decisions based not directly upon the ultimate Darwinian value of gene survival, but upon other more proximal values, such as hedonistic pleasure or something more noble. It was Darwinian selection of genes that built into our brains values such as hedonistic pleasure, orgasm, enjoyment of a sweet taste, or determination to kill oneself in a Jihad – also obviously an un-Darwinian act. It is a manifest fact that the brain – especially the human brain – is well able to over-ride its ultimate programming; well able to dispense with the ultimate value of gene survival and substitute other values. I have used hedonistic pleasure as just an example, but I could also mention more noble values, like a love of poetry, or music, and of course the long-term survival of the planet – and sustainability.

Discussion

Giles Chitty, Independent Financial Adviser: Are there examples of groups of predators who behave in a prudent manner in a way that, perhaps, if they have a maverick among them who is imprudent, they eliminate him? I am thinking strongly of the parallel around Kyoto.

Professor Dawkins: I don't know of any direct examples of that. Something a little like it can happen, at least theoretically, in groups of individuals who know each other as individuals. I think, for example, of pack hunting animals, like wolves, or lions, who are in a certain amount of danger when they attack large prey. One could imagine that some individuals might selfishly hang back and allow the others to bear the brunt of the buffalo's horns. One could also imagine theoretical models in which those who hang back are punished by the other members of the group, noticing that this is going on and driving the shirkers off the kill. But this does not really get to the problem of prudent predation, because we are now talking about a group of animals which know each other and, once you do that, then you are immediately into standard Darwinian theory of reciprocation, which is not to do with long-term altruistic considerations, but can all be handled in short-term language. So, although you probably could find examples which might look superficially like prudence, there are strong theoretical reasons for doubting it.

Phil Clothier, CorpTools UK: What is your definition of a value?

Professor Dawkins: A value is something which is maximised. So, in the case of the ultimate value, what is maximised by all animal and plant behaviour is gene survival. Animals and plants behave as if they had undertaken extremely sophisticated mathematical calculations, in which they are striving to maximise the survival of their genes. That is the ultimate value. More proximally, what animals are maximising are things like a full stomach or an orgasm – something which the nervous system values. The nervous system is pre-equipped with a tendency to value this sensation, whatever it might be, or the sensation of having a nice warm nest – something like that – and this is, from a Darwinian point of view, a proximal value in the service of the ultimate value of gene survival. But the general definition I suppose is something which is maximised.

Jess Kingsford: You say that large brains have been selected through evolution. Do you think that our ability to over-ride our more primal impulses was possibly what was favoured, or what was selected, or is it that what was favoured was the capacity to take the long view?

Professor Dawkins: I think that it was not the capacity to take the long view, in the sense in which all of us here would wish it to be, that was favoured by natural selection. I think that is an emergent property. In the same sort of way, electronic computers were originally built as mathematical calculating engines, and then it was an emergent property that they turned out to be very good at word processing and playing chess and things like that. So the capacity to see into the future would have been a useful thing for the short-term gain, the short-term benefit, of the individual – the capacity to plan a hunt, the capacity to take provision for a drought that's coming, the capacity for storing food for the winter. These are all forward-looking enterprises, but they are all for the selfish gain of the individual. It is that that built into our brains the ability to plan for the future and the ability to plan for the world's future, as opposed to just our own selfish future. That is the emergent property which would never have been directly selected, as such, by Darwinian selection.

Kate Rawles, Philosopher: You talked about the ultimate values that come from Darwinism and then proximal values. What is the relationship between them? What room for manoeuvre have we as humans got and, in particular, are there any constraints on our secondary values that we just can't get?

Professor Dawkins: I speculated that one might breed animals that enjoyed pain, and that would be a fanciful example of changing values. I think your intuition on final constraints is as good as mine. I imagine there are pretty severe limits to what could be achieved by, not necessarily artificial selection, but by training. Could you imagine teaching children to completely reverse normal values? Could you train a group of children to grow up valuing things which are very, very far from what Darwinian selection would have built into them? Imagine bringing up children to kill themselves. That is pushing pretty far away from what Darwinian selection would allow. You are asking how tied are the teachable values to the primary Darwinian values. So, teaching people to kill themselves is pushing it about as far as it can go. In the last couple of months, we have seen disturbing examples where this apparently has been done, so it looks as though, rarely, something like that can happen. I suppose maybe you were asking because of the hope that one might be able to teach people to forgo short-term selfish gain in the interests of long-term world benefit. I am more optimistic about that. There are an awful lot of people who, either for cultural reasons or educational reasons or I don't know quite what, do seem to be capable of subjugating their selfish desires for the good of humanity as a whole, or even living creatures as a whole. The fact that some people seem to manage to do this gives me hope that more people might.

Bob Boote, BTCV: There is so much that is going on today which adds up to evil. What is the value of evil in your context?

Professor Dawkins: I suppose I felt that I did not really need to stress evil because, in a way, many of the things that we call evil do seem to follow more naturally from the Darwinian background. One does not really need to stress that one expects that selfishness, ruthlessness, aggression, riding roughshod over the needs of others weaker than ourselves, are likely to follow from Darwinian natural selection. I suppose I ought to say that, as a passionate Darwinian in the academic sense that I believe Darwinism is the explanation for all of life, I am also a passionate anti-Darwinian when it comes to deriving values for our own life. A pretty good definition of the kind of society in which I don't want to live is a society founded in the principles of Darwinism. That is, in a way, the central message of my lecture.

Michael Quint: You have mentioned the importance of strong policing. Does that not suggest our only hope of going forward is with the much maligned United Nations?

Professor Dawkins: I am naïve about such political matters. I suppose that governments within countries are at least capable, theoretically capable, of the kind of policing I am talking about – making people pay their taxes and suppressing too much manifestation of self interest. When it comes to international interactions, where you do not have world government, organisations such as the one you are citing are the nearest approach we have. It is clear that they are teetering on the edge of being workable, but they do not have the sort of teeth, the sort of powers, that strong governments within countries do.

Dominic Scholfield, People & Planet: I know you have written in the past about the possibility that ideas might develop a Darwinian pattern, using the meme as the unit of cultural transmission that can be replicated. If that is the case – if there is one idea that will survive, is it likely to be sustainability?

Professor Dawkins: The point about memes is that there is nothing special about genes. Darwinism can work with anything which has the property of being a self-replicating entity, which DNA molecules undoubtedly do have. One can theoretically imagine some other things having that property, like computer viruses and perhaps like ideas in a culture. Ideas in a culture may survive in the culture because they have survival value. They have what it takes to survive and if you look around our culture, you see trivial examples, like epidemics, crazes of fashion, games that children play in playgrounds. You are raising the hope that an idea like sustainability might be a good meme and might have a high survival value, in the sense that it would survive, perhaps because a world in which all individuals are imbued with sustainability is a world which is going to continue. Unfortunately that sounds perilously like the group selection argument that I mentioned earlier. One could say the same thing about a species and gene survival. A species, all of whose individuals work for the long-term survival of the species, is more likely to survive than a species whose individuals work for their own selfish good. But it is of the nature of Darwinism that short-term survival is what counts and, if the striving for short-term survival drives the species extinct, that's just too bad. It is too late for natural selection among species, if there were such a thing to come along and save the situation because, by then, the species has already gone extinct. I rather fear the same thing is likely to arise for the meme analogy that you are proposing, but you might come up with an ingenious mathematical model to make it work.

Questioner: How do you work out if you have got to the right level of question rather than the right question?

Professor Dawkins: In the case of the moth and the candle flame, you could first of all check that, given a light source of optical infinity, the moth really does maintain a fixed angle to it. You could then experiment by systematically changing the position of the light to see if the moth changes its own. In other words, see if you can steer the moth just by switching lights on and off. So that would be a test that the moth is actually following that rule. Then I suppose you could test whether the trajectory of the moth in the vicinity of the candle really is a logarithmic spiral, by taking high speed films and analysing that. Let me weaken my position by saying that I am not necessarily saying that any particular 'moth and candle flame' kind of explanation is the right one, but you should be eternally alert to the possibility that the question you are asking is the wrong question. That does not mean you know when you have got the right question. But when somebody challenges you as a Darwinian to explain why people fight over shopping trolleys in Sainsbury's or something, you don't give them a naive answer at the wrong level. You say to yourself, "Moth in candle flame". It is a kind of self-warning.

Questioner: You talked about Darwinism as a framework by which you might be able to understand what conflicts with sustainability. I wonder whether the framework of economics makes better sense? Your example of contraception being rather anti-Darwinian might be very sensible from an economic point of view.

Professor Dawkins: Contraception makes economic sense even from an individual economic point of view. An individual impoverishes himself or herself by having too many children. Yes, economic values – just maximising one's own wealth or any of the other things that economists call utility, whether it is personal wealth or sum of human happiness or whatever it is – all these are values which economists consider might be maximised. Economists, in a way, have an easier time because they are allowed to postulate any kind of utility function, any kind of value that might be maximised, and then look at the consequences. Darwinism is more constrained, in that we know what the fundamental utility function of nature is. It is gene survival. All other utility functions which are not gene survival have to come about as a kind of liberation from the deep Darwinian utility function. But having established that, we can liberate ourselves – and that was one of my central points tonight – we are left with the economists' way of looking at things. What other kinds of utility functions do people maximise and how do they maximise them?

Richard Wilson, Environment Council: You said that people were afraid to enter into international agreements such as the Kyoto Protocol for fear of somehow damaging their own individual position. However, often by entering into dialogue, you actually expose yourself to complex facts and knowledge which will allow you to improve your position. How do you know that you've got the right answer when you don't have all the information?

Professor Dawkins: Uncertainties abound in nature as well. What turns out, as a matter of fact, to be the optimal proximal decision for ultimately maximising the gene survival is never obvious. Animals frequently get it wrong. But the assumption we make is that, in effect, an indefinitely complicated piece of mathematics goes on unconsciously inside the animal. The animal behaves as if it were a very powerful computer which has been programmed by generations of natural selection. Complexity exists in wild nature exactly as it does in the human economic situation. What is more simple in the Darwinian case is that the utility function is known. It is not known how it is maximised. That is extremely complicated, but the utility function is known. In the case of human economic decisions, we don't even know what the utility function is. Different people could be maximising different ones. People could change their minds about what they are maximising. They could have some kind of curious weighted sum of different utility functions. In Darwinism the practice is just as complicated, but the fundamental value is known.

Rt Rev John Oliver, Bishop of Hereford: I speak on environmental issues on behalf of the Church of England. I am wondering whether there is really such a contrast between altruism and self-interest. Is it not possible to say that because we do have very big brains we can understand that it is essential for gene survival that we must have a sustainable future? And that is actually a very hopeful sign?

Professor Dawkins: I agree with that. In different words that is what I was trying to say. Big brains allow you to take a long distance view of your own self-interest and allow you to take actions which natural selection per se could never have allowed you to do. I would resist any suggestion that that is why natural selection gave us the big brains in the first place. I think it is an emergent spin off from the fact that we have big brains for other reasons. But, as a result, we can actually say my long-term self-interest is different from what a naive Darwinian computer would say it is. My long-term self-interest is to forgo short-term benefits in the interests of long-term benefit and that is a hopeful sign, I agree. However, I would shrink from calling it a legitimate evolution of the Darwinian process, because it might be misunderstood as suggesting that natural selection put it there for that reason – in the same way as natural selection put wings on birds so that they could fly. It is a bit of a different thing. I used the word spin-off just now and I think that is about right. There are precedents for that too, of course. The swim bladders of fish, which are used as flotation devices, started out as lungs, and it was a spin-off benefit that they could be used as flotation devices as well. Nature is rife with such cases. They are called pre-adaptations and I think you could say that what we have here is a pre-adaptation.

Anthony Forsyth: Your perspective on sustainability is obviously founded upon the Darwinian beliefs that you hold. However, in environmental circles, there has historically been a great association with different forms of spirituality – not only people like the Bishop, but a vast range of spiritual beliefs. Yet it is apparent from what you are saying that your Darwinian perspective allows very little room for spiritual beliefs. Do you feel that your Darwinian approach to sustainability in practice would be significantly different from an approach to sustainability allowing for a spiritual perspective? Assuming there is a significant difference, is your Darwinian approach to sustainability likely to be broadly adopted within the environmental community?

Professor Dawkins: I don't think it was possible for you to tell from my lecture what my attitude to spiritual beliefs might be.

Anthony Forsyth: It clearly came across as viewing man as a dichotomy of mind and body, with no possibility of a soul. Whatever spiritual beliefs one might have, much of what you were attributing purely to genes would normally be attributed to genes in conjunction with what one might call a soul.

Professor Dawkins: I don't find that a helpful way of looking at the world and so I am not the right person to answer that question. When I say I don't find it a helpful way of looking at the world, that is putting it very mildly indeed.

Sir Geoffrey Chandler: We are enormously grateful to Professor Dawkins for his admirable lecture and generously thoughtful responses to the questions. I am particularly grateful for his confession that he is passionately anti-Darwinian in the context of what we are trying to do. It gives the Foundation courage in our values programme. This is the beginning of a dialogue and not the end of it. Over the next five years, you will be invited to participate in a series of values assessments. The results will be posted on our website. We aim to show how our values change through the use of our thankfully large brains during this period. Finally, we work in partnership with others and if there are those present, individually or institutionally, who would like to participate in what we are trying to do, please do make contact.

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The "Information Challenge": How Evolution Increases Information in the Genome

By Richard Dawkins

In September, 1997, I allowed an Australian film crew into my house in Oxford without realizing that their purpose was creationist propaganda. In the course of a suspiciously amateurish interview, they issued a truculent challenge to me to "give an example of a genetic mutation or an evolutionary process which can be seen to increase the information in the genome." It is the kind of question only a creationist would ask in that way, and it was at this point I tumbled to the fact that I had been duped into granting an interview to creationistsùa thing I normally don't do, for good reasons. In my anger I refused to discuss the question further, and told them to stop the camera.

However, I eventually withdrew my peremptory termination of the interview as a whole. This was solely because they pleaded with me that they had come all the way from Australia specifically in order to interview me. Even if this was a considerable exaggeration, it seemed, on reflection, ungenerous to tear up the legal release form and throw them out. I therefore relented. My generosity was rewarded in a fashion that anyone familiar with fundamentalist tactics might have predicted. When I eventually saw the film a year later, I found that it had been edited to give the false impression that I was incapable of answering the question about information content. (See Barry Williams article in Skeptic Vol. 6, #4, for an account of how my long pause, trying to decide whether to throw them out was made to look like hesitant inability to answer the question, followed by an apparently evasive answer to a completely different question. The exchange between myself, Barry Williams, and the creationists can be found at www.onthenet.com.au/~stear/index.htm)

In fairness, this may not have been quite as intentionally deceitful as it sounds. You have to understand that these people really believe that their question cannot be answered! Pathetic as it sounds, their entire journey from Australia seems to have been a quest to film an evolutionist failing to answer it. With hindsight, given that I had been suckered into admitting them into my house in the first place, it might have been wiser simply to answer the question. But I like to be understood whenever I open my mouth, I have a horror of blinding people with science, and this was not a question that could be answered in a sound bite. First you have to explain the technical meaning of "information." Then the relevance to evolution, too, is complicated, not really difficult but it takes time. Rather than engage now in further recriminations and disputes about exactly what happened at the time of the interview (for, to be fair, I should say that the Australian producer's memory of events seems to differ from mine), I shall try to redress the matter now in constructive fashion by answering the original question, the "Information Challenge," at adequate length, the sort of length you can achieve in a proper article.

Information

The technical definition of "information" was introduced by the American engineer Claude Shannon in 1948. An employee of the Bell Telephone Company, Shannon was concerned to measure information as an economic commodity. It is costly to send messages along a telephone line. Much of what passes in a message is not information: it is redundant. You could save money by recoding the message to remove the redundancy. Redundancy was a second technical term introduced by Shannon, as the inverse of information. Both definitions were mathematical, but we can convey Shannon's intuitive meaning in words. Redundancy is any part of a message that is not informative, either because the recipient already knows it (is not surprised by it) or because it duplicates other parts of the message. In the sentence "Rover is a poodle dog," the word "dog" is redundant because "poodle" already tells us that Rover is a dog. An economical telegram would omit it, thereby increasing the informative proportion of the message. "Arr JFK Fri pm pls mt BA Cncrd flt" carries the same information as the much longer, but more redundant, "I'll be arriving at John F. Kennedy airport on Friday evening; please meet the British Airways Concorde flight." Obviously the brief, telegraphic message is cheaper to send (although the recipient may have to work harder to decipher it, redundancy has its virtues if we forget economics).

Shannon wanted to find a mathematical way to capture the idea that any message could be broken into the information (which is worth paying for), the redundancy (which can, with economic advantage, be deleted from the message because, in effect, it can be reconstructed by the recipient) and the noise (which is just random rubbish). "It rained in Oxford every day this week" carries relatively little information because the receiver is not surprised by it. On the other hand, "It rained in the Sahara desert every day this week" would be a message with high information content, well worth paying extra to send. Shannon wanted to capture this sense of information content as "surprise value." It is related to the other sense, "that which is not duplicated in other parts of the message", because repetitions lose their power to surprise. Note that Shannon's definition of the quantity of information is independent of whether it is true. The measure he came up with was ingenious and intuitively satisfying. Let's estimate, he suggested, the receiver's ignorance or uncertainty before receiving the message, and then compare it with the receiver's remaining ignorance after receiving the message. The quantity of ignorance-reduction is the information content.

Shannon's unit of information is the bit, short for "binary digit." One bit is defined as the amount of information needed to halve the receiver's prior uncertainty, however great that prior uncertainty was (mathematical readers will notice that the bit is, therefore, a logarithmic measure). In practice, you first have to find a way of measuring the prior uncertaintyùthat which is reduced by the information when it comes. For particular kinds of simple message, this is easily done in terms of probabilities. An expectant father watches the Caesarean birth of his child through a window into the operating theatre. He can't see any details, so a nurse has agreed to hold up a pink card if it is a girl, blue for a boy. How much information is conveyed when, say, the nurse flourishes the pink card to the delighted father? The answer is one bit, the prior uncertainty is halved. The father knows that a baby of some kind has been born, so his uncertainty amounts to just two possibilities, boy and girl, and they are (for purposes of this discussion) equal. The pink card halves the father's prior uncertainty from two possibilities to one (girl). If there'd been no pink card but a doctor had walked out of the operating theatre, shook the father's hand and said "Congratulations old chap, I'm delighted to be the first to tell you that you have a daughter," the information conveyed by the 17-word message would still be only one bit.

Computer Information

Computer information is held in a sequence of noughts and ones. There are only two possibilities, so each 0 or 1 can hold one bit. The memory capacity of a computer, or the storage capacity of a disc or tape, is often measured in bits, and this is the total number of 0s or 1s that it can hold. For some purposes, more convenient units of measurement are the byte (8 bits), the kilobyte (1000 bytes or 8000 bits), the megabyte (a million bytes or 8 million bits) or the gigabyte (1000 million bytes or 8000 million bits). Notice that these figures refer to the total available capacity. This is the maximum quantity of information that the device is capable of storing. The actual amount of information stored is something else. The capacity of my hard disc happens to be 4.2 gigabytes. Of this, about 1.4 gigabytes are actually being used to store data at present. But even this is not the true information content of the disc in Shannon's sense. The true information content is smaller, because the information could be more economically stored. You can get some idea of the true information content by using one of those ingenious compression programs like "Stuffit." Stuffit looks for redundancy in the sequence of 0s and 1s, and removes a hefty proportion of it by recoding, stripping out internal predictability. Maximum information content would be achieved (probably never in practice) only if every 1 or 0 surprised us equally. Before data is transmitted in bulk around the Internet, it is routinely compressed to reduce redundancy. That's good economics. But on the other hand it is also a good idea to keep some redundancy in messages, to help correct errors. In a message that is totally free of redundancy, after there's been an error, there is no means of reconstructing what was intended. Computer codes often incorporate deliberately redundant "parity bits" to aid in error detection. DNA, too, has various error-correcting procedures which depend upon redundancy. When I discuss genomes in a moment, I'll return to the three-way distinction between total information capacity, information capacity actually used, and true information content. It was Shannon's insight that information of any kind, no matter what it means, no matter whether it is true or false, and no matter by what physical medium it is carried, can be measured in bits, and is translatable into any other medium of information. The great biologist J. B. S. Haldane used Shannon's theory to compute the number of bits of information conveyed by a worker bee to her hivemates when she "dances" the location of a food source (about 3 bits to tell about the direction of the food and another 3 bits for the distance of the food). In the same units, I recently calculated that I'd need to set aside 120 megabits of laptop computer memory to store the triumphal opening chords of Richard Strauss's "Also Sprach Zarathustra" (the 2001 theme) which I wanted to play in the middle of a lecture about evolution. Shannon's economics enable you to calculate how much modem time it'll cost you to e-mail the complete text of a book to a publisher in another land. Fifty years after Shannon, the idea of information as a commodity, as measurable and interconvertible as money or energy, has come into its own.

DNA Information

DNA carries information in a very computer-like way, and we can measure the genome's capacity in bits too, if we wish. DNA doesn't use a binary code, but a quaternary one. Whereas the unit of information in the computer is a 1 or a 0, the unit in DNA can be T, A, C or G. If I tell you that a particular location in a DNA sequence is a T, how much information is conveyed from me to you? Begin by measuring the prior uncertainty. How many possibilities are open before the message ôTö arrives? Four. How many possibilities remain after it has arrived? One. So you might think the information transferred is four bits, but actually it is two. Here's why (assuming that the four letters are equally probable, like the four suits in a pack of cards).

Remember that Shannon's metric is concerned with the most economical way of conveying the message. Think of it as the number of yes/no questions that you'd have to ask in order to narrow down to certainty, from an initial uncertainty of four possibilities, assuming that you planned your questions in the most economical way. "Is the mystery letter before D in the alphabet?" No. That narrows it down to T or G, and now we need only one more question to clinch it. So, by this method of measuring, each "letter" of the DNA has an information capacity of 2 bits. Whenever prior uncertainty of recipient can be expressed as a number of equiprobable alternatives N, the information content of a message which narrows those alternatives down to one is $\log2^{N}$ (the power to which 2 must be raised in order to yield the number of alternatives N). If you pick a card, any card, from a normal pack, a statement of the identity of the card carries $\log2^{52}$, or 5.7 bits of information. In other words, given a large number of guessing games, it would take 5.7 yes/no questions on average to guess the card, provided the questions are asked in the most economical way. The first two questions might establish the suit (Is it red? Is it a diamond?); the remaining three or four questions would successively divide and conquer the suit (is it a 7 or higher? etc.), finally homing in on the chosen card. When the prior uncertainty is some mixture of alternatives that are not equiprobable, Shannon's formula becomes a slightly more elaborate weighted average, but it is essentially similar. By the way, Shannon's weighted average is the same formula as physicists have used, since the 19th century, for entropy. The point has interesting implications but I shall not pursue them here.

Information and Evolution

That's enough background on information theory. It is a theory which has long held a fascination for me, and I have used it in several of my research papers over the years. Let's now think how we might use it to ask whether the information content of genomes increases in evolution. First, recall the three-way distinction between total information capacity, the capacity that is actually used, and the true information content when stored in the most economical way possible. The total information capacity of the human genome is measured in gigabits. That of the common gut bacterium, Escherichia coli, is measured in megabits. We, like all other animals, are descended from an ancestor which, were it available for our study today, we'd classify as a bacterium. So perhaps, during the billions of years of evolution since that ancestor lived, the information capacity of our genome has gone up about three orders of magnitude (powers of ten)ùabout a thousandfold. This is satisfyingly plausible and comforting to human dignity. Should human dignity feel wounded, then, by the fact that the crested newt, Triturus cristatus, has a genome capacity estimated at 40 gigabits, an order of magnitude larger than the human genome? No, because, in any case, most of the capacity of the genome of any animal is not used to store useful information. There are many nonfunctional pseudogenes (see below) and lots of repetitive nonsense, useful for forensic detectives but not translated into protein in the living cells. The crested newt has a bigger "hard disc" than we have, but since the great bulk of both our hard discs is unused, we needn't feel insulted. Related species of newt have much smaller genomes. Why the Creator should have played fast and loose with the genome sizes of newts in such a capricious way is a problem that creationists might like to ponder. From an evolutionary point of view the explanation is simple (see The Selfish Gene, pp. 44-45 and p. 275 in the Second Edition).

Gene Duplication

Evidently the total information capacity of genomes is very variable across the living kingdoms, and it must have changed greatly in evolution, presumably in both directions. Losses of genetic material are called deletions. New genes arise through various kinds of duplication. This is well illustrated by hemoglobin, the complex protein molecule that transports oxygen in the blood. Human adult hemoglobin is actually a composite of four protein chains called globins, knotted around each other. Their detailed sequences show that the four globin chains are closely related to each other, but they are not identical. Two of them are called alpha globins (each a chain of 141 amino acids), and two are beta globins (each a chain of 146 amino acids). The genes coding for the alpha globins are on Chromosome 11; those coding for the beta globins are on Chromosome 16. On each of these chromosomes, there is a cluster of globin genes in a row, interspersed with some junk DNA. The alpha cluster, on Chromosome 11, contains seven globin genes. Four of these are pseudogenes, versions of alpha disabled by faults in their sequence and not translated into proteins. Two are true alpha globins, used in the adult. The final one is called zeta and is used only in embryos. Similarly the beta cluster, on Chromosome 16, has six genes, some of which are disabled, and one of which is used only in the embryo. Adult hemoglobin, as we've seen, contains two alpha and two beta chains.

Never mind all this complexity. Here's the fascinating point. Careful letter-by-letter analysis shows that these different kinds of globin genes are literally cousins of each other, literally members of a family. But these distant cousins still coexist inside our own genome, and that of all vertebrates. On the scale of whole organisms, the vertebrates are our cousins too. The tree of vertebrate evolution is the family tree we are all familiar with, its branch-points representing speciation events, the splitting of species into pairs of daughter species. But there is another family tree occupying the same time scale, whose branches represent not speciation events but gene duplication events within genomes. The dozen or so different globins inside you are descended from an ancient globin gene which, in a remote ancestor who lived about half a billion years ago, duplicated, after which both copies stayed in the genome. There were then two copies of it, in different parts of the genome of all descendant animals. One copy was destined to give rise to the alpha cluster (on what would eventually become Chromosome 11 in our genome), the other to the beta cluster (on Chromosome 16). As the eons passed, there were further duplications (and doubtless some deletions as well). Around 400 million years ago the ancestral alpha gene duplicated again, but this time the two copies remained near neighbors of each other, in a cluster on the same chromosome. One of them was destined to become the zeta of our embryos, the other became the alpha globin genes of adult humans (other branches gave rise to the nonfunctional pseudogenes I mentioned). It was a similar story along the beta branch of the family, but with duplications at other moments in geological history.

Now here's an equally fascinating point. Given that the split between the alpha cluster and the beta cluster took place 500 million years ago, it will, of course, not be just our human genomes that show the split, possess alpha genes in a different part of the genome from beta genes. We should see the same within-genome split if we look at any other mammals, at birds, reptiles, amphibians and bony fish, for our common ancestor with all of them lived less than 500 million years ago. Wherever it has been investigated, this expectation has proved correct. Our greatest hope of finding a vertebrate that does not share with us the ancient alpha/beta split would be a jawless fish like a lamprey, for they are our most remote cousins among surviving vertebrates; they are the only surviving vertebrates whose common ancestor with the rest of the vertebrates is sufficiently ancient that it could have predated the alpha/beta split.

Sure enough, these jawless fishes are the only known vertebrates that lack the alpha/beta divide. Gene duplication, within the genome, has a similar historic impact to species duplication ("speciation") in phylogeny. It is responsible for gene diversity, in the same way as speciation is responsible for phyletic diversity. Beginning with a single universal ancestor, the magnificent diversity of life has come about through a series of branchings of new species, which eventually gave rise to the major branches of the living kingdoms and the hundreds of millions of separate species that have graced the earth. A similar series of branchings, but this time within genomes, gene duplications, has spawned the large and diverse population of clusters of genes that constitutes the modern genome.

The story of the globins is just one among many. Gene duplications and deletions have occurred from time to time throughout genomes. It is by these and similar means that genome sizes can increase in evolution. But remember the distinction between the total capacity of the whole genome, and the capacity of the portion that is actually used. Recall that not all the globin genes are actually used. Some of them, like theta in the alpha cluster of globin genes, are pseudogenes, recognizably kin to functional genes in the same genomes, but never actually translated into the action language of protein. What is true of globins is true of most other genes. Genomes are littered with nonfunctional pseudogenes, faulty duplicates of functional genes that do nothing, while their functional cousins (the word doesn't even need scare quotes) get on with their business in a different part of the same genome. And there's lots more DNA that doesn't even deserve the name pseudogene. It, too, is derived by duplication, but not duplication of functional genes. It consists of multiple copies of junk, "tandem repeats," and other nonsense which may be useful for forensic detectives but which doesn't seem to be used in the body itself. Once again, creationists might spend some earnest time speculating on why the Creator should bother to litter genomes with untranslated pseudogenes and junk tandem repeat DNA.

Information in the Genome

Can we measure the information capacity of that portion of the genome which is actually used? We can at least estimate it. In the case of the human genome it is about 2%, considerably less than the proportion of my hard disc that I have ever used since I bought it. Presumably the equivalent figure for the crested newt is even smaller, but I don't know if it has been measured. In any case, we mustn't run away with a chauvinistic idea that the human genome somehow ought to have the largest DNA database because we are so wonderful. The great evolutionary biologist George C. Williams has pointed out that animals with complicated life cycles need to code for the development of all stages in the life cycle, but they only have one genome with which to do so. A butterfly's genome has to hold the complete information needed for building a caterpillar as well as a butterfly. A sheep liver fluke has six distinct stages in its life cycle, each specialized for a different way of life. We shouldn't feel too insulted if liver flukes turned out to have bigger genomes than we have (actually they don't). Remember, too, that even the total capacity of genome that is actually used is still not the same thing as the true information content in Shannon's sense. The true information content is what's left when the redundancy has been compressed out of the message, by the theoretical equivalent of Stuffit. There are even some viruses which seem to use a kind of Stuffit-like compression. They make use of the fact that the RNA code (not DNA in these viruses, as it happens, but the principle is the same) is read in triplets. There is a "frame" which moves along the RNA sequence, reading off three letters at a time. Obviously, under normal conditions, if the frame starts reading in the wrong place (as in a so-called frame-shift mutation), it makes total nonsense: the "triplets" that it reads are out of step with the meaningful ones. But these splendid viruses actually exploit frame-shifted reading. They get two messages for the price of one, by having a completely different message embedded in the very same series of letters when read frame-shifted. In principle you could even get three messages for the price of one, but I don't know whether there are any examples.

Information in the Body

It is one thing to estimate the total information capacity of a genome, and the amount of the genome that is actually used, but it's harder to estimate its true information content in the Shannon sense. The best we can do is probably to forget about the genome itself and look at its product, the "phenotype," the working body of the animal or plant itself. In 1951, J. W. S. Pringle, who later became my professor at Oxford, suggested using a Shannon-type information measure to estimate "complexity." Pringle wanted to express complexity mathematically in bits, but I have long found the following verbal form helpful in explaining his idea to students. We have an intuitive sense that a lobster, say, is more complex (more "advanced," some might even say more "highly evolved") than another animal, perhaps a millipede. Can we measure something in order to confirm or deny our intuition? Without literally turning it into bits, we can make an approximate estimation of the information contents of the two bodies as follows. Imagine writing a book describing the lobster. Now write another book describing the millipede down to the same level of detail. Divide the word-count in one book by the word-count in the other, and you have an approximate estimate of the relative information content of lobster and millipede. It is important to specify that both books describe their respective animals "down to the same level of detail."

Obviously if we describe the millipede down to cellular detail, but stick to gross anatomical features in the case of the lobster, the millipede would come out ahead. But if we do the test fairly, I'll bet the lobster book would come out longer than the millipede book. It's a simple plausibility argument, as follows. Both animals are made up of segments, modules of bodily architecture that are fundamentally similar to each other, arranged fore-and-aft like the cars of a train. The millipede's segments are mostly identical to each other. The lobster's segments, though following the same basic plan (each with a nervous ganglion, a pair of appendages, and so on) are mostly different from each other. The millipede book would consist of one chapter describing a typical segment, followed by the phrase "Repeat N times" where N is the number of segments. The lobster book would need a different chapter for each segment. This isn't quite fair to the millipede, whose front and rear end segments are a bit different from the rest. But I'd still bet that, if anyone bothered to do the experiment, the estimate of lobster information content would come out substantially greater than the estimate of millipede information content. It's not of direct evolutionary interest to compare a lobster with a millipede in this way, because nobody thinks lobsters evolved from millipedes. Obviously no modern animal evolved from any other modern animal. Instead, any pair of modern animals had a last common ancestor which lived at some (in principle) discoverable moment in geological history.

Almost all of evolution happened way back in the past, which makes it hard to study details. But we can use the "length of book" thought-experiment to agree upon what it would mean to ask the question whether information content increases over evolution, if only we had ancestral animals to look at. The answer in practice is complicated and controversial, all bound up with a vigorous debate over whether evolution is, in general, progressive. I am one of those associated with a limited form of yes answer. My colleague Stephen Jay Gould tends towards a no answer. I don't think anybody would deny that, by any method of measuring, whether bodily information content, total information capacity of genome, capacity of genome actually used, or true ("Stuffit compressed") information content of genome, there has been a broad overall trend towards increased information content during the course of human evolution from our remote bacterial ancestors.

People might disagree, however, over two important questions: first, whether such a trend is to be found in all, or a majority of evolutionary lineages (for example parasite evolution often shows a trend towards decreasing bodily complexity, because parasites are better off being simple); second, whether, even in lineages where there is a clear overall trend over the very long term, it is bucked by so many reversals and re-reversals in the shorter term as to undermine the very idea of progress. This is not the place to resolve this interesting controversy. There are distinguished biologists with good arguments on both sides. Supporters of "intelligent design" guiding evolution, by the way, should be deeply committed to the view that information content increases during evolution. Even if the information comes from God, perhaps especially if it does, it should surely increase, and the increase should presumably show itself in the genome. Unless, of course (and anything goes in such addle-brained theorizing), God works his evolutionary miracles by nongenetic means.

Perhaps the main lesson we should learn from Pringle is that the information content of a biological system is another name for its complexity. Therefore the creationist challenge with which we began is tantamount to the standard challenge to explain how biological complexity can evolve from simpler antecedents, one that I have devoted three books to answering (The Blind Watchmaker, River Out of Eden, Climbing Mount Improbable) and I do not propose to repeat their contents here. The "information challenge" turns out to be none other than our old friend: "How could something as complex as an eye evolve?" It is just dressed up in fancy mathematical language, perhaps in an attempt to bamboozle. Or perhaps those who ask it have already bamboozled themselves, and don't realize that it is the same old and thoroughly answered question.

The Genetic Book of the Dead

Let me turn, finally, to another way of looking at whether the information content of genomes increases in evolution. We now switch from the broad sweep of evolutionary history to the minutiae of natural selection. Natural selection itself, when you think about it, is a narrowing down from a wide initial field of possible alternatives, to the narrower field of the alternatives actually chosen. Random genetic error (mutation), sexual recombination and migratory mixing all provide a wide field of genetic variation: the available alternatives. Mutation is not an increase in true information content, rather the reverse, for mutation, in the Shannon analogy, contributes to increasing the prior uncertainty.

But now we come to natural selection, which reduces the "prior uncertainty" and therefore, in Shannon's sense, contributes information to the gene pool. In every generation, natural selection removes the less successful genes from the gene pool, so the remaining gene pool is a narrower subset. The narrowing is nonrandom, in the direction of improvement, where improvement is defined, in the Darwinian way, as improvement in fitness to survive and reproduce. Of course, the total range of variation is topped up again in every generation by new mutation and other kinds of variation. But it still remains true that natural selection is a narrowing down from an initially wider field of possibilities, including mostly unsuccessful ones, to a narrower field of successful ones. This is analogous to the definition of information with which we began: information is what enables the narrowing down from prior uncertainty (the initial range of possibilities) to later certainty (the "successful" choice among the prior probabilities). According to this analogy, natural selection is by definition a process whereby information is fed into the gene pool of the next generation.

If natural selection feeds information into gene pools, what is the information about? It is about how to survive. Strictly, it is about how to survive and reproduce in the conditions that prevailed when previous generations were alive. To the extent that present day conditions are different from ancestral conditions, the ancestral genetic advice will be wrong. In extreme cases, the species may then go extinct. To the extent that conditions for the present generation are not too different from conditions for past generations, the information fed into present-day genomes from past generations is helpful information. Information from the ancestral past can be seen as a manual for surviving in the present: a family Bible of ancestral "advice" on how to survive today. We need only a little poetic license to say that the information fed into modern genomes by natural selection is actually information about ancient environments in which ancestors survived. This idea of information fed from ancestral generations into descendant gene pools is one of the themes of my new book, Unweaving the Rainbow. It takes a whole chapter, "The Genetic Book of the Dead," to develop the notion, so I won't repeat it here except to say two things. First, it is the gene pool of the species as a whole, not the genome of any particular individual, which is best seen as the recipient of the ancestral information about how to survive. The genomes of particular individuals are random samples of the current gene pool, randomised by sexual recombination. Second, we are privileged to "intercept" the information if we wish, and "read" an animal's body, or even its genes, as a coded description of ancestral worlds. To quote from Unweaving the Rainbow: "And isn't it an arresting thought? We are digital archives of the African Pliocene, even of Devonian seas; walking repositories of wisdom out of the old days. You could spend a lifetime reading in this ancient library and die unsated by the wonder of it."

Religion's misguided missiles

Promise a young man that death is not the end and he will willingly cause disaster

The following Richard Dawkins essay appeared in the popular U.K. news website,The Guardian on September 15, 2001, four days after the World Trade Center terrorist attack.

A guided missile corrects its trajectory as it flies, homing in, say, on the heat of a jet plane's exhaust. A great improvement on a simple ballistic shell, it still cannot discriminate particular targets. It could not zero in on a designated New York skyscraper if launched from as far away as Boston.

That is precisely what a modern "smart missile" can do. Computer miniaturisation has advanced to the point where one of today's smart missiles could be programmed with an image of the Manhattan skyline together with instructions to home in on the north tower of the World Trade Centre. Smart missiles of this sophistication are possessed by the United States, as we learned in the Gulf war, but they are economically beyond ordinary terrorists and scientifically beyond theocratic governments. Might there be a cheaper and easier alternative?

In the second world war, before electronics became cheap and miniature, the psychologist BF Skinner did some research on pigeon-guided missiles. The pigeon was to sit in a tiny cockpit, having previously been trained to peck keys in such a way as to keep a designated target in the centre of a screen. In the missile, the target would be for real.

The principle worked, although it was never put into practice by the US authorities. Even factoring in the costs of training them, pigeons are cheaper and lighter than computers of comparable effectiveness. Their feats in Skinner's boxes suggest that a pigeon, after a regimen of training with colour slides, really could guide a missile to a distinctive landmark at the southern end of Manhattan island. The pigeon has no idea that it is guiding a missile. It just keeps on pecking at those two tall rectangles on the screen, from time to time a food reward drops out of the dispenser, and this goes on until... oblivion.

Pigeons may be cheap and disposable as on-board guidance systems, but there's no escaping the cost of the missile itself. And no such missile large enough to do much damage could penetrate US air space without being intercepted. What is needed is a missile that is not recognised for what it is until too late. Something like a large civilian airliner, carrying the innocuous markings of a well-known carrier and a great deal of fuel. That's the easy part. But how do you smuggle on board the necessary guidance system? You can hardly expect the pilots to surrender the left-hand seat to a pigeon or a computer.

How about using humans as on-board guidance systems, instead of pigeons?

Humans are at least as numerous as pigeons, their brains are not significantly costlier than pigeon brains, and for many tasks they are actually superior. Humans have a proven track record in taking over planes by the use of threats, which work because the legitimate pilots value their own lives and those of their passengers.

The natural assumption that the hijacker ultimately values his own life too, and will act rationally to preserve it, leads air crews and ground staff to make calculated decisions that would not work with guidance modules lacking a sense of self-preservation. If your plane is being hijacked by an armed man who, though prepared to take risks, presumably wants to go on living, there is room for bargaining. A rational pilot complies with the hijacker's wishes, gets the plane down on the ground, has hot food sent in for the passengers and leaves the negotiations to people trained to negotiate.

The problem with the human guidance system is precisely this. Unlike the pigeon version, it knows that a successful mission culminates in its own destruction. Could we develop a biological guidance system with the compliance and dispensability of a pigeon but with a man's resourcefulness and ability to infiltrate plausibly? What we need, in a nutshell, is a human who doesn't mind being blown up. He'd make the perfect on-board guidance system. But suicide enthusiasts are hard to find. Even terminal cancer patients might lose their nerve when the crash was actually looming.

Could we get some otherwise normal humans and somehow persuade them that they are not going to die as a consequence of flying a plane smack into a skyscraper? If only! Nobody is that stupid, but how about this - it's a long shot, but it just might work. Given that they are certainly going to die, couldn't we sucker them into believing that they are going to come to life again afterwards? Don't be daft! No, listen, it might work. Offer them a fast track to a Great Oasis in the Sky, cooled by everlasting fountains. Harps and wings wouldn't appeal to the sort of young men we need, so tell them there's a special martyr's reward of 72 virgin brides, guaranteed eager and exclusive.

Would they fall for it? Yes, testosterone-sodden young men too unattractive to get a woman in this world might be desperate enough to go for 72 private virgins in the next.

It's a tall story, but worth a try. You'd have to get them young, though. Feed them a complete and self-consistent background mythology to make the big lie sound plausible when it comes. Give them a holy book and make them learn it by heart. Do you know, I really think it might work. As luck would have it, we have just the thing to hand: a ready-made system of mind-control which has been honed over centuries, handed down through generations. Millions of people have been brought up in it. It is called religion and, for reasons which one day we may understand, most people fall for it (nowhere more so than America itself, though the irony passes unnoticed). Now all we need is to round up a few of these faith-heads and give them flying lessons.

Facetious? Trivialising an unspeakable evil? That is the exact opposite of my intention, which is deadly serious and prompted by deep grief and fierce anger. I am trying to call attention to the elephant in the room that everybody is too polite - or too devout - to notice: religion, and specifically the devaluing effect that religion has on human life. I don't mean devaluing the life of others (though it can do that too), but devaluing one's own life. Religion teaches the dangerous nonsense that death is not the end.

If death is final, a rational agent can be expected to value his life highly and be reluctant to risk it. This makes the world a safer place, just as a plane is safer if its hijacker wants to survive. At the other extreme, if a significant number of people convince themselves, or are convinced by their priests, that a martyr's death is equivalent to pressing the hyperspace button and zooming through a wormhole to another universe, it can make the world a very dangerous place. Especially if they also believe that that other universe is a paradisical escape from the tribulations of the real world. Top it off with sincerely believed, if ludicrous and degrading to women, sexual promises, and is it any wonder that naive and frustrated young men are clamouring to be selected for suicide missions?

There is no doubt that the afterlife-obsessed suicidal brain really is a weapon of immense power and danger. It is comparable to a smart missile, and its guidance system is in many respects superior to the most sophisticated electronic brain that money can buy. Yet to a cynical government, organisation, or priesthood, it is very very cheap.

Our leaders have described the recent atrocity with the customary cliche: mindless cowardice. "Mindless" may be a suitable word for the vandalising of a telephone box. It is not helpful for understanding what hit New York on September 11. Those people were not mindless and they were certainly not cowards. On the contrary, they had sufficiently effective minds braced with an insane courage, and it would pay us mightily to understand where that courage came from.

It came from religion. Religion is also, of course, the underlying source of the divisiveness in the Middle East which motivated the use of this deadly weapon in the first place. But that is another story and not my concern here. My concern here is with the weapon itself. To fill a world with religion, or religions of the Abrahamic kind, is like littering the streets with loaded guns. Do not be surprised if they are used.

The Improbability of God

by Richard Dawkins

The following article is from Free Inquiry MagazineVolume 18, Number 3.

Much of what people do is done in the name of God. Irishmen blow each other up in his name. Arabs blow themselves up in his name. Imams and ayatollahs oppress women in his name. Celibate popes and priests mess up people's sex lives in his name. Jewish *shohets* cut live animals' throats in his name. The achievements of religion in past history - bloody crusades, torturing inquisitions, mass-murdering conquistadors, culture-destroying missionaries, legally enforced resistance to each new piece of scientific truth until the last possible moment - are even more impressive. And what has it all been in aid of? I believe it is becoming increasingly clear that the answer is absolutely nothing at all. There is no reason for believing that any sort of gods exist and quite good reason for believing that they do not exist and never have. It has all been a gigantic waste of time and a waste of life. It would be a joke of cosmic proportions if it weren't so tragic.

Why do people believe in God? For most people the answer is still some version of the ancient Argument from Design. We look about us at the beauty and intricacy of the world - at the aerodynamic sweep of a swallow's wing, at the delicacy of flowers and of the butterflies that fertilize them, through a microscope at the teeming life in every drop of pond water, through a telescope at the crown of a giant redwood tree. We reflect on the electronic complexity and optical perfection of our own eyes that do the looking. If we have any imagination, these things drive us to a sense of awe and reverence. Moreover, we cannot fail to be struck by the obvious resemblance of living organs to the carefully planned designs of human engineers. The argument was most famously expressed in the watchmaker analogy of the eighteenth-century priest William Paley. Even if you didn't know what a watch was, the obviously designed character of its cogs and springs and of how they mesh together for a purpose would force you to conclude "that the watch must have had a maker: that there must have existed, at some time, and at some place or other, an artificer or artificers, who formed it for the purpose which we find it actually to answer; who comprehended its construction, and designed its use." If this is true of a comparatively simple watch, how much the more so is it true of the eye, ear, kidney, elbow joint, brain? These beautiful, complex, intricate, and obviously purpose-built structures must have had their own designer, their own watchmaker - God.

So ran Paley's argument, and it is an argument that nearly all thoughtful and sensitive people discover for themselves at some stage in their childhood. Throughout most of history it must have seemed utterly convincing, self-evidently true. And yet, as the result of one of the most astonishing intellectual revolutions in history, we now know that it is wrong, or at least superfluous. We now know that the order and apparent purposefulness of the living world has come about through an entirely different process, a process that works without the need for any designer and one that is a consequence of basically very simple laws of physics. This is the process of evolution by natural selection, discovered by

Charles Darwin and, independently, by Alfred Russel Wallace.

What do all objects that look as if they must have had a designer have in common? The answer is statistical improbability. If we find a transparent pebble washed into the shape of a crude lens by the sea, we do not conclude that it must have been designed by an optician: the unaided laws of physics are capable of achieving this result; it is not too improbable to have just "happened." But if we find an elaborate compound lens, carefully corrected against spherical and chromatic aberration, coated against glare, and with "Carl Zeiss" engraved on the rim, we know that it could not have just happened by chance. If you take all the atoms of such a compound lens and throw them together at random under the jostling influence of the ordinary laws of physics in nature, it is *theoretically* possible that, by sheer luck, the atoms would just happen to fall into the pattern of a Zeiss compound lens, and even that the atoms round the rim should happen to fall in such a way that the name Carl Zeiss is etched out. But the number of other ways in which the atoms could, with equal likelihood, have fallen, is so hugely, vastly, immeasurably greater that we can completely discount the chance hypothesis. Chance is out of the question as an explanation.

This is not a circular argument, by the way. It might seem to be circular because, it could be said, *any* particular arrangement of atoms is, with hindsight, very improbable. As has been said before, when a ball lands on a particular blade of grass on the golf course, it would be foolish to exclaim: "Out of all the billions of blades of grass that it *could* have fallen on, the ball actually fell on this one. How amazingly, miraculously improbable!" The fallacy here, of course, is that the ball had to land somewhere. We can only stand amazed at the improbability of the actual event if we specify it *a priori*: for example, if a blindfolded man spins himself round on the tee, hits the ball at random, and achieves a hole in one. That would be truly amazing, because the target destination of the ball is specified in advance.

Of all the trillions of different ways of putting together the atoms of a telescope, only a minority would actually work in some useful way. Only a tiny minority would have Carl Zeiss engraved on them, or, indeed, *any* recognizable words of any human language. The same goes for the parts of a watch: of all the billions of possible ways of putting them together, only a tiny minority will tell the time or do anything useful. And of course the same goes, *a fortiori*, for the parts of a living body. Of all the trillions of trillions of ways of putting together the parts of a body, only an infinitesimal minority would live, seek food, eat, and reproduce. True, there are many different ways of being alive - at least ten million different ways if we count the number of distinct species alive today - but, however many ways there may be of being alive, it is certain that there are vastly more ways of being dead!

We can safely conclude that living bodies are billions of times too complicated - too statistically improbable - to have come into being by sheer chance. How, then, did they come into being? The answer is that chance enters into the story, but not a single, monolithic act of chance. Instead, a whole series of tiny chance steps, each one small enough to be a believable product of its predecessor, occurred one after the other in sequence. These small steps of chance are caused by genetic mutations, random changes - mistakes really - in the genetic material. They give rise to changes in the existing bodily structure. Most of these changes are deleterious and lead to death. A minority of them turn out to be slight improvements, leading to increased survival and reproduction. By this process of natural selection, those random changes that turn out to be beneficial eventually spread through the species and become the norm. The stage is now set for the next small change in the evolutionary process. After, say, a thousand of these small changes in series, each change providing the basis for the next, the end result has become, by a process of accumulation, far too complex to have come about in a single act of chance.

For instance, it is theoretically possible for an eye to spring into being, in a single lucky step, from nothing: from bare skin, let's say. It is theoretically possible in the sense that a recipe could be written out in the form of a large number of mutations. If all these mutations happened simultaneously, a complete eye could, indeed, spring from nothing. But although it is theoretically possible, it is in practice inconceivable. The quantity of luck involved is much too large. The "correct" recipe involves changes in a huge number of genes simultaneously. The correct recipe is one particular combination of changes out of trillions of equally probable combinations of chances. We can certainly rule out such a miraculous coincidence. But it *is* perfectly plausible that the modern eye could have sprung from something almost the same as the modern eye but not quite: a very slightly less elaborate eye. By the same argument, this slightly less elaborate eye sprang from a slightly less elaborate eye still, and so on. If you assume a *sufficiently large number of sufficiently small differences* between each evolutionary stage and its predecessor, you are bound to be able to derive a full, complex, working eye from bare skin. How many intermediate stages are we allowed to postulate? That depends on how much time we have to play with. Has there been enough time for eyes to evolve by little steps from nothing?

The fossils tell us that life has been evolving on Earth for more than 3,000 million years. It is almost impossible for the human mind to grasp such an immensity of time. We, naturally and mercifully, tend to see our own expected lifetime as a fairly long time, but we can't expect to live even one century. It is 2,000 years since Jesus lived, a time span long enough to blur the distinction between history and myth. Can you imagine a million such periods laid end to end? Suppose we wanted to write the whole history on a single long scroll. If we crammed all of Common Era history into one metre of scroll, how long would the pre-Common Era part of the scroll, back to the start of evolution, be? The answer is that the pre-Common Era part of the scroll would stretch from Milan to Moscow. Think of the implications of this for the quantity of evolutionary change that can be accommodated. All the domestic breeds of dogs - Pekingeses, poodles, spaniels, Saint Bernards, and Chihuahuas - have come from wolves in a time span measured in hundreds or at the most thousands of years: no more than two meters along the road from Milan to Moscow. Think of the quantity of change involved in going from a wolf to a Pekingese; now multiply that quantity of change by a million. When you look at it like that, it becomes easy to believe that an eye could have evolved from no eye by small degrees.

It remains necessary to satisfy ourselves that every one of the intermediates on the evolutionary route, say from bare skin to a modern eye, would have been favored by natural selection; would have been an improvement over its predecessor in the sequence or at least would have survived. It is no good proving to ourselves that there is theoretically a chain of almost perceptibly different intermediates leading to an eye if many of those intermediates would have died. It is sometimes argued that the parts of an eye have to be all there together or the eye won't work at all. Half an eye, the argument runs, is no better than no eye at all. You can't fly with half a wing; you can't hear with half an ear. Therefore there can't have been a series of step-by-step intermediates leading up to a modern eye, wing, or ear.

This type of argument is so naive that one can only wonder at the subconscious motives for wanting to believe it. It is obviously not true that half an eye is useless. Cataract sufferers who have had their lenses surgically removed cannot see very well without glasses, but they are still much better off than people with no eyes at all. Without a lens you can't focus a detailed image, but you can avoid bumping into obstacles and you could detect the looming shadow of a predator.

As for the argument that you can't fly with only half a wing, it is disproved by large numbers of very successful gliding animals, including mammals of many different kinds, lizards, frogs, snakes, and squids. Many different kinds of tree-dwelling animals have flaps of skin between their joints that really are fractional wings. If you fall out of a tree, any skin flap or flattening of the body that increases your surface area can save your life. And, however small or large your flaps may be, there must always be a critical height such that, if you fall from a tree of that height, your life would have been saved by just a little bit more surface area. Then, when your descendants have evolved that extra surface area, their lives would be saved by just a bit more still if they fell from trees of a slightly greater height. And so on by insensibly graded steps until, hundreds of generations later, we arrive at full wings.

Eyes and wings cannot spring into existence in a single step. That would be like having the almost infinite luck to hit upon the combination number that opens a large bank vault. But if you spun the dials of the lock at random, and every time you got a little bit closer to the lucky number the vault door creaked open another chink, you would soon have the door open! Essentially, that is the secret of how evolution by natural selection achieves what once seemed impossible. Things that cannot plausibly be derived from very different predecessors *can* plausibly be derived from only slightly different predecessors. Provided only that there is a sufficiently long series of such slightly different predecessors, you can derive anything from anything else.

Evolution, then, is theoretically *capable* of doing the job that, once upon a time, seemed to be the prerogative of God. But is there any evidence that evolution actually has happened? The answer is yes; the evidence is overwhelming. Millions of fossils are found in exactly the places and at exactly the depths that we should expect if evolution had happened. Not a single fossil has ever been found in any place where the evolution theory would not have expected it, although this *could* very easily have happened: a fossil mammal in rocks so old that fishes have not yet arrived, for instance, would be enough to disprove the evolution theory.

The patterns of distribution of living animals and plants on the continents and islands of the world is exactly what would be expected if they had evolved from common ancestors by slow, gradual degrees. The patterns of resemblance among animals and plants is exactly what we should expect if some were close cousins, and others more distant cousins to each other. The fact that the genetic code is the same in all living creatures overwhelmingly suggests that all are descended from one single ancestor. The evidence for evolution is so compelling that the only way to save the creation theory is to assume that God deliberately planted enormous quantities of evidence to make it *look* as if evolution had happened. In other words, the fossils, the geographical distribution of animals, and so on, are all one gigantic confidence trick. Does anybody want to worship a God capable of such trickery? It is surely far more reverent, as well as more scientifically sensible, to take the evidence at face value. All living creatures are cousins of one another, descended from one remote ancestor that lived more than 3,000 million years ago.

The Argument from Design, then, has been destroyed as a reason for believing in a God. Are there any other arguments? Some people believe in God because of what appears to them to be an inner revelation. Such revelations are not always edifying but they undoubtedly feel real to the individual concerned. Many inhabitants of lunatic asylums have an unshakable inner faith that they are Napoleon or, indeed, God himself. There is no doubting the power of such convictions for those that have them, but this is no reason for the rest of us to believe them. Indeed, since such beliefs are mutually contradictory, we can't believe them all.

There is a little more that needs to be said. Evolution by natural selection explains a lot, but it couldn't start from nothing. It couldn't have started until there was some kind of rudimentary reproduction and heredity. Modern heredity is based on the DNA code, which is itself too complicated to have sprung spontaneously into being by a single act of chance. This seems to mean that there must have been some earlier hereditary system, now disappeared, which was simple enough to have arisen by chance and the laws of chemistry and which provided the medium in which a primitive form of cumulative natural selection could get started. DNA was a later product of this earlier cumulative selection. Before this original kind of natural selection, there was a period when complex chemical compounds were built up from simpler ones and before that a period when the chemical elements were built up from simpler elements, following the well-understood laws of physics. Before that, everything was ultimately built up from pure hydrogen in the immediate aftermath of the big bang, which initiated the universe.

There is a temptation to argue that, although God may not be needed to explain the evolution of complex order once the universe, with its fundamental laws of physics, had begun, we do need a God to explain the origin of all things. This idea doesn't leave God with very much to do: just set off the big bang, then sit back and wait for everything to happen. The physical chemist Peter Atkins, in his beautifully written book *The Creation*, postulates a lazy God who strove to do as little as possible in order to initiate everything. Atkins explains how each step in the history of the universe followed, by simple physical law, from its predecessor. He thus pares down the amount of work that the lazy creator would need to do and eventually concludes that he would in fact have needed to do nothing at all!

The details of the early phase of the universe belong to the realm of physics, whereas I am a biologist, more concerned with the later phases of the evolution of complexity. For me, the important point is that, even if the physicist needs to postulate an irreducible minimum that had to be present in the beginning, in order for the universe to get started, that irreducible minimum is certainly extremely simple. By definition, explanations that build on simple premises are more plausible and more satisfying than explanations that have to postulate complex and statistically improbable beginnings. And you can't get much more complex than an Almighty God!

A Reformed Response To:

Is Science a Religion?, by Richard Dawkins, The Humanist, Jan./Feb. 1997., pp 26-29

by Jonathan Barlow

Introduction

The article presently under examination is a transcript of a speech made to the American Humanist Association by Richard Dawkins on the occasion of his being named "Humanist of the Year, 1996". Filled with his customary rhetorical excess (and also his much-appreciated humor), Dawkins' speech provides a good opportunity for Christians to take note of the role of presuppositions in every intellectual endeavor and the role of self-deception in unbelief.

The Faith of Science

Dawkins begins his speech by comparing the threat of AIDS and "mad-cow" disease to the threat posed by faith. He writes that faith is "one of the world's great evils, comparable to the smallpox virus but harder to eradicate" (p 26). Dawkins defines faith as "belief that isn't based on evidence" and calls it the "principle [*sic*] vice of any religion" (*ibid).* Reformed Christians realize that this definition of faith is a caricature. Instead of viewing faith as belief that is not based upon evidence, we view faith as that which is a pre-condition for gaining any other knowledge; faith itself is not irrational or unscientific, but that which must be in order to gain other knowledge through science and logic. For instance, confidence in the law of non-contradiction could be said to be faith. There is no direct way to prove the law of contradiction except that it must be presupposed in order to learn anything or differentiate anything from anything else. Likewise, the principle of induction, which states that the future will be generally like the past, is what makes possible the formulation of scientific laws and theories. We cannot test the truth of this principle scientifically, for we would be assuming the truth of induction to try and prove it. We cannot test the truth of the principle logically, for logic has as its subject matter static propositions. Thus, induction and the law of contradiction, two of the bedrocks upon which all the rest of Richard Dawkins' knowledge is based, are both things he must accept on faith. Dawkins does not believe this, however, and directs this entire speech at demolishing the notion that science is a religion, or at least a faith-based discipline.

Dawkins and the Apostle Thomas

Dawkins writes, "Well, science is not religion and it doesn't just come down to faith. Although it has many of religion's virtues, it has none of its vices. Science is based upon verifiable evidences" (27). What we have seen above, however, is that science is based upon evidences which are themselves held to be true because of principles which are accepted on faith, induction and the laws of logic. No understanding of the philosophy of science seems to be evidenced by Dawkins' statements. He, in fact, appears to have the same honorific view of science as the technology-stunned *hoi polloi*. Dawkins compares science, which he sees as being based upon "verifiable evidence" with religion which he says shouts "independence from evidence" from the rooftops (*ibid*.). This is why, he says, we Christians criticize Thomas, the disciple who doubted Jesus' resurrection. He writes, "The other apostles are held up to us as exemplars of virtue because faith was enough for them. Doubting Thomas, on the other hand, required evidence. Perhaps he should be the patron saint of scientists" (27). Let us examine the Thomas story, so as not to let any of Dawkins' erroneous statements pass by without comment.

First of all, Dawkins says that the disciples only believed based upon faith. This is not at all accurate. In John 20:19 and following we find Jesus, after his resurrection, appearing miraculously in a locked room among the disciples. He "came and stood among them and said, 'Peace be with you!' After he said this, he showed them his hands and side. The disciples were overjoyed when they saw the Lord" (Jn 20:19,20). Jesus not only appears to them, but he also shows them his wounded side and wounded hands to prove to them that he is the crucified, but ressurected Jesus. Where is the faith here?

Well, Thomas wasn't with the other disciples, so they reported to him what they had seen. Ten of his best friends all reported to him the same thing, that Jesus was resurrected. He did not believe them, however. Is this because he refused to believe on faith? No. There was the evidence of ten eyewitnesses, and yet he refused to believe, even given all the miraculous things he had already witnessed. How many journal articles must Dawkins read before he agrees with the findings of the scientific community? Has he seen all the calculations which allow us to postulate the existence of sub-atomic particles? Doesn't the testimony of witnesses count as evidence for Dawkins? I would imagine so, or else he would be forced to personally verify every experiment upon which he bases his current research.

Thomas' answer is more revealing of his attitude than his evidential requirements. He says to his 10 closest friends, whose word he doubts, "Unless I see the nail marks in the hands and put my finger where the nails were, and put my hand into his side, I will not believe it" (Jn 20:25). Notice how strident Thomas' evidential ultimatum is. One thing that should be clear is that one's expectation for verification must match the entity under question. What if I stated, "I will not believe in the existence of Saltine Crackers until I eat one and it makes a sweet taste in my mouth"? This would be absurd. I would be requiring verification that is not and could not be accessible to me -- verification inappropriate to the entity under question. Suppose Jesus had come back with a non-scarred side and non-scarred hands. Suppose he appeared to the ten and then decided to re-enter heaven. Thomas' requirement for verification would be unreasonable. As it turns out, Thomas may not have even fulfilled his stated evidential standards before he believed. When confronted with Jesus personally, Thomas can do nothing but declare "My Lord and my God!" (v 28). Jesus' response is perhaps where Dawkins and the rest of the atheistic or so-called "freethought" community have received their impetus to use Thomas as the poster-child for Enlightenment rationalism and Baconian empiricism. He says to Thomas, "Because you have seen me, you have believed; blessed are those who have not seen and yet have believed" (29). In context, this quote is easily understood to be speaking of a different kind of belief required in the post-apostolic era. In the Gospels are recorded many miraculous acts of Jesus. Many who witnessed these events with their very eyes did not even believe! Some did, however. Now that Jesus is returning to heaven, there will be no chance to believe based upon sight. One must believe based upon the testimony of the apostles. Thomas' brand of faith is inappropriate for the apostolic era and beyond. Analogously, I must believe in the assasination of Abraham Lincoln based upon the testimony of witnesses. I cannot demand to see the event personally in order to believe it. Such a requirement is inappropriate for this time in history. Thomas, likewise, is held up to be an example of one whose brand of faith was too crude for the coming era. The question is not faith versus evidence, but what kind of evidence! If believing the testimony of witnesses is a kind of faith that scientists are not to embrace, then why are there scientific journals? *(Dawkins here may well respond that scientists often include their data in journal articles, and thus their experiments can be checked. But who is to say that the scientists are honest in the reporting of their findings?)*

Dawkins and Morality

On page 27, Dawkins calls faith a "vice". He criticizes scientists who falsify evidence. He calls science "one of the most moral, one of the most honest disciplines around - because science would completely collapse if it weren't for a scrupulous adherence to honesty in the reporting of evidence". He criticizes the law profession for being based upon the falsifying, or at least the twisting, of evidence. On page 28 he calls religious instruction "mental child abuse" stating that it is wrong to inculcate children in a particular religion. On page 29, Dawkins draws a finer point on the issue of morality writing, "When the religious education class turns to ethics, I don't think science actually has a lot to say, and I would replace it with rational moral philosophy." Further, "It's a rewarding question, whatever your personal morality, to ask as an evolutionist where morals come from; by what route has the human brain gained its tendency to have ethics and morals, a feeling of right and wrong?" He hints that a "thinking and feeling chimpanzee" should have more rights than "a human fetus with the faculties of a worm". He writes, responding to the charge of scientific zealotry, "Sometimes there may be a little bit of justice in this accusation; but as zealous bigots, we scientists are mere amateurs at the game. We're content to argue with those who disagree with us. We don't kill them". Here, apparently, Dawkins means to say that arguing is morally better than killing. As the above testifies, it is truly amazing how much time Dawkins devotes to ethical issues. Let us ask, however, what kind of pronouncements Dawkins is able to make about ethical issues given his view of the world.

For Dawkins, human beings are animals that have evolved from lower forms of life and ultimately from non-life. They have material brains which have formed alongside material arms, legs, and colons. Somehow, a sense of feeling that some things are right and wrong have welled up in the human mind over the course of evolution. Ethical feelings are epiphenomena, feelings that have developed out of the chemical construction of the brain which itself evolved to possess this capacity. What does this mean? This means that ethical norms are like opposable thumbs, an inherited trait that has evolved gradually from non-life. Ultimately, in Dawkins' particular scientific world-view, there is nothing but matter. Thus, ethical obligations are mere feelings like indigestion or fear. How then, does Dawkins make pronouncements about how children ought to be taught? How does he know that it is better to let them decide about religion for themselves? Suppose someone else felt the epiphenomenon of obligation to teach his children his own religion. How does Dawkins propose going about arbitrating between the two feelings, his and the religious educator? He offers one alternative - rational moral philosophy, a discipline which has not exactly been responsible for very much agreement in the past! How does he decide which is more rational, killing someone for fun or killing someone in self-defense? It seems that since the former produces the state of mind "fun" and the latter is simply a response to the negative state of mind "fear", the former is a more positive, and thus presumably a more rational, thing to seek out. Of course, he is no more able to define rationality in terms of his Darwinistic world-view than he is able to define the ethical. For both are mere epiphenomena like fear, pain or pre-menstrual syndrome. Dawkins would do well to avoid altogether this subject for which his own world-view provides no answers, only a morass. In Dawkins' world-view, people are just animals battling it out in history -- it is no more ethical to let our children decide for themselves about religious issues than it is to grind them up and use them to fertilize the family garden.

Christianity, however, provides a coherent basis for ethics. There is an absolute person, God, and thus his unchanging character, and the ethical aspects of his character, can serve as absolute ethical norms. An added element is that with the character of an absolute God as our guide for ethical obligations we are not left in the dark because God is a person who can reveal his character to us. Not only are there obligations, then, but we can know them. The amazing amount of consolation Dawkins receives from his self-satisfaction with atheistic ethics is further evidence of his self-deception with regard to the possibility of ethics within his world-view. At least Christianity provides the ethical tools needed to critique the behavior of its own. Christians can condemn the actions of the Spanish Inquisition. Scientists like Dawkins, however, cannot even give a coherent reason for why the biological experiments of the Nazis were unethical.

Dawkins and Awe

Dawkins writes,

> "All the great religions have a place for awe, for ecstatic transport at the wonder and beauty of creation. And it's exactly this feeling of spine-shivering, breath-catching awe - almost worship - this flooding of the chest with ecstatic wonder, that modern science can provide ... The merest glance through a microscope at the brain of an ant or through a telescope at a long-ago galaxy of a billion worlds is enough to render poky and parochial the very psalms of praise" (27).

Later, however, he writes, "we know from the second law of thermodynamics that all complexity, all life, all laughter, all sorrow, is hell-bent on leveling itself out into cold nothingness in the end. They - and we - can never be more than temporary, local buckings of the great universal slide into the abyss of uniformity" (29). So is science a good source of encouragement and awe, or for despair and nihilism? Dawkins' universe is one in which humans are animals presently evolving and battling it out until the time when the "sun will engulf the earth" (29). I'm not so sure that Dawkins has made his case that science replaces religion's sense of wonder and awe. Assume for a moment that an absolute person designed and created the ant's brain with all of its minute detail; assume for a moment that a loving God made the crab nebula and the planets and stars in all their vast array! Which is more awe-inspiring, the creation or the creator? I'm not giving an argument for God's existence, here, only that given his existence as creator, he is more awesome than the creation.

Conclusion

I would do well at this point to break away and leave Dawkins in the morass of his purely contingent universe in which not even logic, science, and morality make any sense. For all of his huff and puff against faith, Dawkins lives in a drafty house of pure scientism that he has sealed up with faith -- faith in logic, of whose foundations he can give no account, faith in induction, upon which he builds science, and faith in the evolving human brain and the evolving human society to more often produce Martin Luther Kings than John Wayne Gacys.

For Further Reading

Van Til, Cornelius. Why I Believe in God.

Frame, John and Martin, Michael, *A Debate Concerning the Transcendental Argument for the Existence of God.*

Bahnsen, Greg L. *The Crucial Concept of Self-Deception in Presuppositional Apologetics*, WTJ Vol. 57, No. 1, Spring 1995. pp 1-31.

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Religion's misguided missiles

Promise a young man that death is not the end and he will willingly cause disaster

The following Richard Dawkins essay appeared in the popular U.K. news website,The Guardian on September 15, 2001, four days after the World Trade Center terrorist attack.

A guided missile corrects its trajectory as it flies, homing in, say, on the heat of a jet plane's exhaust. A great improvement on a simple ballistic shell, it still cannot discriminate particular targets. It could not zero in on a designated New York skyscraper if launched from as far away as Boston.

That is precisely what a modern "smart missile" can do. Computer miniaturisation has advanced to the point where one of today's smart missiles could be programmed with an image of the Manhattan skyline together with instructions to home in on the north tower of the World Trade Centre. Smart missiles of this sophistication are possessed by the United States, as we learned in the Gulf war, but they are economically beyond ordinary terrorists and scientifically beyond theocratic governments. Might there be a cheaper and easier alternative?

In the second world war, before electronics became cheap and miniature, the psychologist BF Skinner did some research on pigeon-guided missiles. The pigeon was to sit in a tiny cockpit, having previously been trained to peck keys in such a way as to keep a designated target in the centre of a screen. In the missile, the target would be for real.

The principle worked, although it was never put into practice by the US authorities. Even factoring in the costs of training them, pigeons are cheaper and lighter than computers of comparable effectiveness. Their feats in Skinner's boxes suggest that a pigeon, after a regimen of training with colour slides, really could guide a missile to a distinctive landmark at the southern end of Manhattan island. The pigeon has no idea that it is guiding a missile. It just keeps on pecking at those two tall rectangles on the screen, from time to time a food reward drops out of the dispenser, and this goes on until... oblivion.

Pigeons may be cheap and disposable as on-board guidance systems, but there's no escaping the cost of the missile itself. And no such missile large enough to do much damage could penetrate US air space without being intercepted. What is needed is a missile that is not recognised for what it is until too late. Something like a large civilian airliner, carrying the innocuous markings of a well-known carrier and a great deal of fuel. That's the easy part. But how do you smuggle on board the necessary guidance system? You can hardly expect the pilots to surrender the left-hand seat to a pigeon or a computer.

How about using humans as on-board guidance systems, instead of pigeons? Humans are at least as numerous as pigeons, their brains are not significantly costlier than pigeon brains, and for many tasks they are actually superior. Humans have a proven track record in taking over planes by the use of threats, which work because the legitimate pilots value their own lives and those of their passengers.

The natural assumption that the hijacker ultimately values his own life too, and will act rationally to preserve it, leads air crews and ground staff to make calculated decisions that

would not work with guidance modules lacking a sense of self-preservation. If your plane is being hijacked by an armed man who, though prepared to take risks, presumably wants to go on living, there is room for bargaining. A rational pilot complies with the hijacker's wishes, gets the plane down on the ground, has hot food sent in for the passengers and leaves the negotiations to people trained to negotiate.

The problem with the human guidance system is precisely this. Unlike the pigeon version, it knows that a successful mission culminates in its own destruction. Could we develop a biological guidance system with the compliance and dispensability of a pigeon but with a man's resourcefulness and ability to infiltrate plausibly? What we need, in a nutshell, is a human who doesn't mind being blown up. He'd make the perfect on-board guidance system. But suicide enthusiasts are hard to find. Even terminal cancer patients might lose their nerve when the crash was actually looming.

Could we get some otherwise normal humans and somehow persuade them that they are not going to die as a consequence of flying a plane smack into a skyscraper? If only! Nobody is that stupid, but how about this - it's a long shot, but it just might work. Given that they are certainly going to die, couldn't we sucker them into believing that they are going to come to life again afterwards? Don't be daft! No, listen, it might work. Offer them a fast track to a Great Oasis in the Sky, cooled by everlasting fountains. Harps and wings wouldn't appeal to the sort of young men we need, so tell them there's a special martyr's reward of 72 virgin brides, guaranteed eager and exclusive.

Would they fall for it? Yes, testosterone-sodden young men too unattractive to get a woman in this world might be desperate enough to go for 72 private virgins in the next.

It's a tall story, but worth a try. You'd have to get them young, though. Feed them a complete and self-consistent background mythology to make the big lie sound plausible when it comes. Give them a holy book and make them learn it by heart. Do you know, I really think it might work. As luck would have it, we have just the thing to hand: a ready-made system of mind-control which has been honed over centuries, handed down through generations. Millions of people have been brought up in it. It is called religion and, for reasons which one day we may understand, most people fall for it (nowhere more so than America itself, though the irony passes unnoticed). Now all we need is to round up a few of these faith-heads and give them flying lessons.

Facetious? Trivialising an unspeakable evil? That is the exact opposite of my intention, which is deadly serious and prompted by deep grief and fierce anger. I am trying to call attention to the elephant in the room that everybody is too polite - or too devout - to notice: religion, and specifically the devaluing effect that religion has on human life. I don't mean devaluing the life of others (though it can do that too), but devaluing one's own life. Religion teaches the dangerous nonsense that death is not the end.

If death is final, a rational agent can be expected to value his life highly and be reluctant to risk it. This makes the world a safer place, just as a plane is safer if its hijacker wants to survive. At the other extreme, if a significant number of people convince themselves, or are convinced by their priests, that a martyr's death is equivalent to pressing the hyperspace button and zooming through a wormhole to another universe, it can make the world a very dangerous place. Especially if they also believe that that other universe is a paradisical

escape from the tribulations of the real world. Top it off with sincerely believed, if ludicrous and degrading to women, sexual promises, and is it any wonder that naive and frustrated young men are clamouring to be selected for suicide missions?

There is no doubt that the afterlife-obsessed suicidal brain really is a weapon of immense power and danger. It is comparable to a smart missile, and its guidance system is in many respects superior to the most sophisticated electronic brain that money can buy. Yet to a cynical government, organisation, or priesthood, it is very very cheap.

Our leaders have described the recent atrocity with the customary cliche: mindless cowardice. "Mindless" may be a suitable word for the vandalising of a telephone box. It is not helpful for understanding what hit New York on September 11. Those people were not mindless and they were certainly not cowards. On the contrary, they had sufficiently effective minds braced with an insane courage, and it would pay us mightily to understand where that courage came from.

It came from religion. Religion is also, of course, the underlying source of the divisiveness in the Middle East which motivated the use of this deadly weapon in the first place. But that is another story and not my concern here. My concern here is with the weapon itself. To fill a world with religion, or religions of the Abrahamic kind, is like littering the streets with loaded guns. Do not be surprised if they are used.

The Improbability of God

by Richard Dawkins

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Much of what people do is done in the name of God. Irishmen blow each other up in his name. Arabs blow themselves up in his name. Imams and ayatollahs oppress women in his name. Celibate popes and priests mess up people's sex lives in his name. Jewish *shohets* cut live animals' throats in his name. The achievements of religion in past history - bloody crusades, torturing inquisitions, mass-murdering conquistadors, culture-destroying missionaries, legally enforced resistance to each new piece of scientific truth until the last possible moment - are even more impressive. And what has it all been in aid of? I believe it is becoming increasingly clear that the answer is absolutely nothing at all. There is no reason for believing that any sort of gods exist and quite good reason for believing that they do not exist and never have. It has all been a gigantic waste of time and a waste of life. It would be a joke of cosmic proportions if it weren't so tragic.

Why do people believe in God? For most people the answer is still some version of the ancient Argument from Design. We look about us at the beauty and intricacy of the world - at the aerodynamic sweep of a swallow's wing, at the delicacy of flowers and of the butterflies that fertilize them, through a microscope at the teeming life in every drop of pond water, through a telescope at the crown of a giant redwood tree. We reflect on the electronic complexity and optical perfection of our own eyes that do the looking. If we have any imagination, these things drive us to a sense of awe and reverence. Moreover, we cannot fail to be struck by the obvious resemblance of living organs to the carefully planned designs of human engineers. The argument was most famously expressed in the watchmaker analogy of the eighteenth-century priest William Paley. Even if you didn't know what a watch was, the obviously designed character of its cogs and springs and of how they mesh together for a purpose would force you to conclude "that the watch must have had a maker: that there must have existed, at some time, and at some place or other, an artificer or artificers, who formed it for the purpose which we find it actually to answer; who comprehended its construction, and designed its use." If this is true of a comparatively simple watch, how much the more so is it true of the eye, ear, kidney, elbow joint, brain? These beautiful, complex, intricate, and obviously purpose-built structures must have had their own designer, their own watchmaker - God.

So ran Paley's argument, and it is an argument that nearly all thoughtful and sensitive people discover for themselves at some stage in their childhood. Throughout most of history it must have seemed utterly convincing, self-evidently true. And yet, as the result of one of the most astonishing intellectual revolutions in history, we now know that it is wrong, or at least superfluous. We now know that the order and apparent purposefulness of the living world has come about through an entirely different process, a process that works without the need for any designer and one that is a consequence of basically very simple laws of physics. This is the process of evolution by natural selection, discovered by Charles Darwin and, independently, by Alfred Russel Wallace.

What do all objects that look as if they must have had a designer have in common? The answer is statistical improbability. If we find a transparent pebble washed into the shape of a crude lens by the sea, we do not conclude that it must have been designed by an

optician: the unaided laws of physics are capable of achieving this result; it is not too improbable to have just "happened." But if we find an elaborate compound lens, carefully corrected against spherical and chromatic aberration, coated against glare, and with "Carl Zeiss" engraved on the rim, we know that it could not have just happened by chance. If you take all the atoms of such a compound lens and throw them together at random under the jostling influence of the ordinary laws of physics in nature, it is *theoretically* possible that, by sheer luck, the atoms would just happen to fall into the pattern of a Zeiss compound lens, and even that the atoms round the rim should happen to fall in such a way that the name Carl Zeiss is etched out. But the number of other ways in which the atoms could, with equal likelihood, have fallen, is so hugely, vastly, immeasurably greater that we can completely discount the chance hypothesis. Chance is out of the question as an explanation.

This is not a circular argument, by the way. It might seem to be circular because, it could be said, *any* particular arrangement of atoms is, with hindsight, very improbable. As has been said before, when a ball lands on a particular blade of grass on the golf course, it would be foolish to exclaim: "Out of all the billions of blades of grass that it *could* have fallen on, the ball actually fell on this one. How amazingly, miraculously improbable!" The fallacy here, of course, is that the ball had to land somewhere. We can only stand amazed at the improbability of the actual event if we specify it *a priori*: for example, if a blindfolded man spins himself round on the tee, hits the ball at random, and achieves a hole in one. That would be truly amazing, because the target destination of the ball is specified in advance.

Of all the trillions of different ways of putting together the atoms of a telescope, only a minority would actually work in some useful way. Only a tiny minority would have Carl Zeiss engraved on them, or, indeed, *any* recognizable words of any human language. The same goes for the parts of a watch: of all the billions of possible ways of putting them together, only a tiny minority will tell the time or do anything useful. And of course the same goes, *a fortiori*, for the parts of a living body. Of all the trillions of trillions of ways of putting together the parts of a body, only an infinitesimal minority would live, seek food, eat, and reproduce. True, there are many different ways of being alive - at least ten million different ways if we count the number of distinct species alive today - but, however many ways there may be of being alive, it is certain that there are vastly more ways of being dead!

We can safely conclude that living bodies are billions of times too complicated - too statistically improbable - to have come into being by sheer chance. How, then, did they come into being? The answer is that chance enters into the story, but not a single, monolithic act of chance. Instead, a whole series of tiny chance steps, each one small enough to be a believable product of its predecessor, occurred one after the other in sequence. These small steps of chance are caused by genetic mutations, random changes - mistakes really - in the genetic material. They give rise to changes in the existing bodily structure. Most of these changes are deleterious and lead to death. A minority of them turn out to be slight improvements, leading to increased survival and reproduction. By this process of natural selection, those random changes that turn out to be beneficial eventually spread through the species and become the norm. The stage is now set for the next small change in the evolutionary process. After, say, a thousand of these small changes in series, each change providing the basis for the next, the end result has become, by a process of accumulation, far too complex to have come about in a single act of chance.

For instance, it is theoretically possible for an eye to spring into being, in a single lucky step, from nothing: from bare skin, let's say. It is theoretically possible in the sense that a recipe could be written out in the form of a large number of mutations. If all these mutations happened simultaneously, a complete eye could, indeed, spring from nothing. But although it is theoretically possible, it is in practice inconceivable. The quantity of luck involved is much too large. The "correct" recipe involves changes in a huge number of genes simultaneously. The correct recipe is one particular combination of changes out of trillions of equally probable combinations of chances. We can certainly rule out such a miraculous coincidence. But it *is* perfectly plausible that the modern eye could have sprung from something almost the same as the modern eye but not quite: a very slightly less elaborate eye. By the same argument, this slightly less elaborate eye sprang from a slightly less elaborate eye still, and so on. If you assume a *sufficiently large number of sufficiently small differences* between each evolutionary stage and its predecessor, you are bound to be able to derive a full, complex, working eye from bare skin. How many intermediate stages are we allowed to postulate? That depends on how much time we have to play with. Has there been enough time for eyes to evolve by little steps from nothing?

The fossils tell us that life has been evolving on Earth for more than 3,000 million years. It is almost impossible for the human mind to grasp such an immensity of time. We, naturally and mercifully, tend to see our own expected lifetime as a fairly long time, but we can't expect to live even one century. It is 2,000 years since Jesus lived, a time span long enough to blur the distinction between history and myth. Can you imagine a million such periods laid end to end? Suppose we wanted to write the whole history on a single long scroll. If we crammed all of Common Era history into one metre of scroll, how long would the pre-Common Era part of the scroll, back to the start of evolution, be? The answer is that the pre-Common Era part of the scroll would stretch from Milan to Moscow. Think of the implications of this for the quantity of evolutionary change that can be accommodated. All the domestic breeds of dogs - Pekingeses, poodles, spaniels, Saint Bernards, and Chihuahuas - have come from wolves in a time span measured in hundreds or at the most thousands of years: no more than two meters along the road from Milan to Moscow. Think of the quantity of change involved in going from a wolf to a Pekingese; now multiply that quantity of change by a million. When you look at it like that, it becomes easy to believe that an eye could have evolved from no eye by small degrees.

It remains necessary to satisfy ourselves that every one of the intermediates on the evolutionary route, say from bare skin to a modern eye, would have been favored by natural selection; would have been an improvement over its predecessor in the sequence or at least would have survived. It is no good proving to ourselves that there is theoretically a chain of almost perceptibly different intermediates leading to an eye if many of those intermediates would have died. It is sometimes argued that the parts of an eye have to be all there together or the eye won't work at all. Half an eye, the argument runs, is no better than no eye at all. You can't fly with half a wing; you can't hear with half an ear. Therefore there can't have been a series of step-by-step intermediates leading up to a modern eye, wing, or ear.

This type of argument is so naive that one can only wonder at the subconscious motives for wanting to believe it. It is obviously not true that half an eye is useless. Cataract sufferers who have had their lenses surgically removed cannot see very well without glasses, but they are still much better off than people with no eyes at all. Without a lens you can't focus a detailed image, but you can avoid bumping into obstacles and you could

detect the looming shadow of a predator.

As for the argument that you can't fly with only half a wing, it is disproved by large numbers of very successful gliding animals, including mammals of many different kinds, lizards, frogs, snakes, and squids. Many different kinds of tree-dwelling animals have flaps of skin between their joints that really are fractional wings. If you fall out of a tree, any skin flap or flattening of the body that increases your surface area can save your life. And, however small or large your flaps may be, there must always be a critical height such that, if you fall from a tree of that height, your life would have been saved by just a little bit more surface area. Then, when your descendants have evolved that extra surface area, their lives would be saved by just a bit more still if they fell from trees of a slightly greater height. And so on by insensibly graded steps until, hundreds of generations later, we arrive at full wings.

Eyes and wings cannot spring into existence in a single step. That would be like having the almost infinite luck to hit upon the combination number that opens a large bank vault. But if you spun the dials of the lock at random, and every time you got a little bit closer to the lucky number the vault door creaked open another chink, you would soon have the door open! Essentially, that is the secret of how evolution by natural selection achieves what once seemed impossible. Things that cannot plausibly be derived from very different predecessors *can* plausibly be derived from only slightly different predecessors. Provided only that there is a sufficiently long series of such slightly different predecessors, you can derive anything from anything else.

Evolution, then, is theoretically *capable* of doing the job that, once upon a time, seemed to be the prerogative of God. But is there any evidence that evolution actually has happened? The answer is yes; the evidence is overwhelming. Millions of fossils are found in exactly the places and at exactly the depths that we should expect if evolution had happened. Not a single fossil has ever been found in any place where the evolution theory would not have expected it, although this *could* very easily have happened: a fossil mammal in rocks so old that fishes have not yet arrived, for instance, would be enough to disprove the evolution theory.

The patterns of distribution of living animals and plants on the continents and islands of the world is exactly what would be expected if they had evolved from common ancestors by slow, gradual degrees. The patterns of resemblance among animals and plants is exactly what we should expect if some were close cousins, and others more distant cousins to each other. The fact that the genetic code is the same in all living creatures overwhelmingly suggests that all are descended from one single ancestor. The evidence for evolution is so compelling that the only way to save the creation theory is to assume that God deliberately planted enormous quantities of evidence to make it *look* as if evolution had happened. In other words, the fossils, the geographical distribution of animals, and so on, are all one gigantic confidence trick. Does anybody want to worship a God capable of such trickery? It is surely far more reverent, as well as more scientifically sensible, to take the evidence at face value. All living creatures are cousins of one another, descended from one remote ancestor that lived more than 3,000 million years ago.

The Argument from Design, then, has been destroyed as a reason for believing in a God. Are there any other arguments? Some people believe in God because of what appears to them to be an inner revelation. Such revelations are not always edifying but they undoubtedly feel real to the individual concerned. Many inhabitants of lunatic asylums have

an unshakable inner faith that they are Napoleon or, indeed, God himself. There is no doubting the power of such convictions for those that have them, but this is no reason for the rest of us to believe them. Indeed, since such beliefs are mutually contradictory, we can't believe them all.

There is a little more that needs to be said. Evolution by natural selection explains a lot, but it couldn't start from nothing. It couldn't have started until there was some kind of rudimentary reproduction and heredity. Modern heredity is based on the DNA code, which is itself too complicated to have sprung spontaneously into being by a single act of chance. This seems to mean that there must have been some earlier hereditary system, now disappeared, which was simple enough to have arisen by chance and the laws of chemistry and which provided the medium in which a primitive form of cumulative natural selection could get started. DNA was a later product of this earlier cumulative selection. Before this original kind of natural selection, there was a period when complex chemical compounds were built up from simpler ones and before that a period when the chemical elements were built up from simpler elements, following the well-understood laws of physics. Before that, everything was ultimately built up from pure hydrogen in the immediate aftermath of the big bang, which initiated the universe.

There is a temptation to argue that, although God may not be needed to explain the evolution of complex order once the universe, with its fundamental laws of physics, had begun, we do need a God to explain the origin of all things. This idea doesn't leave God with very much to do: just set off the big bang, then sit back and wait for everything to happen. The physical chemist Peter Atkins, in his beautifully written book *The Creation*, postulates a lazy God who strove to do as little as possible in order to initiate everything. Atkins explains how each step in the history of the universe followed, by simple physical law, from its predecessor. He thus pares down the amount of work that the lazy creator would need to do and eventually concludes that he would in fact have needed to do nothing at all!

The details of the early phase of the universe belong to the realm of physics, whereas I am a biologist, more concerned with the later phases of the evolution of complexity. For me, the important point is that, even if the physicist needs to postulate an irreducible minimum that had to be present in the beginning, in order for the universe to get started, that irreducible minimum is certainly extremely simple. By definition, explanations that build on simple premises are more plausible and more satisfying than explanations that have to postulate complex and statistically improbable beginnings. And you can't get much more complex than an Almighty God!

Viruses of the Mind
Richard Dawkins

1991

> The haven all memes depend on reaching is the human mind, but a human mind is itself an artifact created when memes restructure a human brain in order to make it a better habitat for memes. The avenues for entry and departure are modified to suit local conditions, and strengthened by various artificial devices that enhance fidelity and prolixity of replication: native Chinese minds differ dramatically from native French minds, and literate minds differ from illiterate minds. What memes provide in return to the organisms in which they reside is an incalculable store of advantages --- with some Trojan horses thrown in for good measure. . .
>
> Daniel Dennett, *Consciousness Explained*

1 Duplication Fodder

A beautiful child close to me, six and the apple of her father's eye, believes that Thomas the Tank Engine really exists. She believes in Father Christmas, and when she grows up her ambition is to be a tooth fairy. She and her school-friends believe the solemn word of respected adults that tooth fairies and Father Christmas really exist. This little girl is of an age to believe whatever you tell her. If you tell her about witches changing princes into frogs she will believe you. If you tell her that bad children roast forever in hell she will have nightmares. I have just discovered that without her father's consent this sweet, trusting, gullible six-year-old is being sent, for weekly instruction, to a Roman Catholic nun. What chance has she?

A human child is shaped by evolution to soak up the culture of her people. Most obviously, she learns the essentials of their language in a matter of months. A large dictionary of words to speak, an encyclopedia of information to speak about, complicated syntactic and semantic rules to order the speaking, are all transferred from older brains into hers well before she reaches half her adult size. When you are pre-programmed to absorb useful information at a high rate, it is hard to shut out pernicious or damaging information at the same time. With so many mindbytes to be downloaded, so many mental codons to be replicated, it is no wonder that child brains are gullible, open to almost any suggestion, vulnerable to subversion, easy prey to Moonies, Scientologists and nuns. Like immune-deficient patients, children are wide open to mental infections that adults might brush off without effort.

DNA, too, includes parasitic code. Cellular machinery is extremely good at copying DNA. Where DNA is concerned, it seems to have an eagerness to copy, seems eager to be copied. The cell nucleus is a paradise for DNA, humming with sophisticated, fast, and accurate duplicating machinery.

Cellular machinery is so friendly towards DNA duplication that it is small wonder cells play host to DNA parasites --- viruses, viroids, plasmids and a riff-raff of other genetic fellow travelers. Parasitic DNA even gets itself spliced seamlessly into the chromosomes themselves. ``Jumping genes'' and stretches of ``selfish DNA'' cut or copy themselves out of chromosomes and paste themselves in elsewhere. Deadly oncogenes are almost impossible to distinguish from the legitimate genes

between which they are spliced. In evolutionary time, there is probably a continual traffic from ``straight" genes to ``outlaw," and back again (Dawkins, 1982). DNA is just DNA. The only thing that distinguishes viral DNA from host DNA is its expected method of passing into future generations. ``Legitimate" host DNA is just DNA that aspires to pass into the next generation via the orthodox route of sperm or egg. ``Outlaw" or parasitic DNA is just DNA that looks to a quicker, less cooperative route to the future, via a squeezed droplet or a smear of blood, rather than via a sperm or egg.

For data on a floppy disc, a computer is a humming paradise just as cell nuclei hum with eagerness to duplicate DNA. Computers and their associated disc and tape readers are designed with high fidelity in mind. As with DNA molecules, magnetized bytes don't literally ``want" to be faithfully copied. Nevertheless, you can write a computer program that takes steps to duplicate itself. Not just duplicate itself within one computer but spread itself to other computers. Computers are so good at copying bytes, and so good at faithfully obeying the instructions contained in those bytes, that they are sitting ducks to self-replicating programs: wide open to subversion by software parasites. Any cynic familiar with the theory of selfish genes and memes would have known that modern personal computers, with their promiscuous traffic of floppy discs and e-mail links, were just asking for trouble. The only surprising thing about the current epidemic of computer viruses is that it has been so long in coming.

2 Computer Viruses: a Model for an Informational Epidemiology

Computer viruses are pieces of code that graft themselves into existing, legitimate programs and subvert the normal actions of those programs. They may travel on exchanged floppy disks, or over networks. They are technically distinguished from ``worms" which are whole programs in their own right, usually traveling over networks. Rather different are ``Trojan horses," a third category of destructive programs, which are not in themselves self-replicating but rely on humans to replicate them because of their pornographic or otherwise appealing content. Both viruses and worms are programs that actually say, in computer language, ``Duplicate me." Both may do other things that make their presence felt and perhaps satisfy the hole-in-corner vanity of their authors. These side-effects may be ``humorous" (like the virus that makes the Macintosh's built-in loudspeaker enunciate the words ``Don't panic," with predictably opposite effect); malicious (like the numerous IBM viruses that erase the hard disk after a sniggering screen-announcement of the impending disaster); political (like the Spanish Telecom and Beijing viruses that protest about telephone costs and massacred students respectively); or simply inadvertent (the programmer is incompetent to handle the low-level system calls required to write an effective virus or worm). The famous Internet Worm, which paralyzed much of the computing power of the United States on November 2, 1988, was not intended (very) maliciously but got out of control and, within 24 hours, had clogged around 6,000 computer memories with exponentially multiplying copies of itself.

``Memes now spread around the world at the speed of light, and replicate at rates that make even fruit flies and yeast cells look glacial in comparison. They leap promiscuously from vehicle to vehicle, and from medium to medium, and are proving to be virtually unquarantinable" (Dennett 1990, p.131). Viruses aren't limited to electronic media such as disks and data lines. On its way from one computer to another, a virus may pass through printing ink, light rays in a human lens, optic nerve impulses and finger muscle contractions. A computer fanciers' magazine that printed the text of a virus program for the interest of its readers has been widely condemned. Indeed, such is the appeal of the virus idea to a certain kind of puerile mentality (the masculine gender is used

advisedly), that publication of any kind of ``how to'' information on designing virus programs is rightly seen as an irresponsible act.

I am not going to publish any virus code. But there are certain tricks of effective virus design that are sufficiently well known, even obvious, that it will do no harm to mention them, as I need to do to develop my theme. They all stem from the virus's need to evade detection while it is spreading.

A virus that clones itself too prolifically within one computer will soon be detected because the symptoms of clogging will become too obvious to ignore. For this reason many virus programs check, before infecting a system, to make sure that they are not already on that system. Incidentally, this opens the way for a defense against viruses that is analogous to immunization. In the days before a specific anti-virus program was available, I myself responded to an early infection of my own hard disk by means of a crude ``vaccination.'' Instead of deleting the virus that I had detected, I simply disabled its coded instructions, leaving the ``shell'' of the virus with its characteristic external ``signature'' intact. In theory, subsequent members of the same virus species that arrived in my system should have recognized the signature of their own kind and refrained from trying to double-infect. I don't know whether this immunization really worked, but in those days it probably was worth while ``gutting'' a virus and leaving a shell like this, rather than simply removing it lock, stock and barrel. Nowadays it is better to hand the problem over to one of the professionally written anti-virus programs.

A virus that is too virulent will be rapidly detected and scotched. A virus that instantly and catastrophically sabotages every computer in which it finds itself will not find itself in many computers. It may have a most amusing effect on one computer ---- erase an entire doctoral thesis or something equally side-splitting --- but it won't spread as an epidemic.

Some viruses, therefore, are designed to have an effect that is small enough to be difficult to detect, but which may nevertheless be extremely damaging. There is one type, which, instead of erasing disk sectors wholesale, attacks only spreadsheets, making a few random changes in the (usually financial) quantities entered in the rows and columns. Other viruses evade detection by being triggered probabilistically, for example erasing only one in 16 of the hard disks infected. Yet other viruses employ the time-bomb principle. Most modern computers are ``aware'' of the date, and viruses have been triggered to manifest themselves all around the world, on a particular date such as Friday 13th or April Fool's Day. From the parasitic point of view, it doesn't matter how catastrophic the eventual attack is, provided the virus has had plenty of opportunity to spread first (a disturbing analogy to the Medawar/Williams theory of ageing: we are the victims of lethal and sub-lethal genes that mature only after we have had plenty of time to reproduce (Williams, 1957)). In defense, some large companies go so far as to set aside one ``miner's canary'' among their fleet of computers, and advance its internal calendar a week so that any time-bomb viruses will reveal themselves prematurely before the big day.

Again predictably, the epidemic of computer viruses has triggered an arms race. Anti-viral software is doing a roaring trade. These antidote programs -- ``Interferon,'' ``Vaccine,'' ``Gatekeeper'' and others --- employ a diverse armory of tricks. Some are written with specific, known and named viruses in mind. Others intercept any attempt to meddle with sensitive system areas of memory and warn the user.

The virus principle could, in theory, be used for non-malicious, even beneficial purposes. Thimbleby (1991) coins the phrase ``liveware'' for his already-implemented use of the infection principle for keeping multiple copies of databases up to date. Every time a disk containing the database is

plugged into a computer, it looks to see whether there is already another copy present on the local hard disk. If there is, each copy is updated in the light of the other. So, with a bit of luck, it doesn't matter which member of a circle of colleagues enters, say, a new bibliographical citation on his personal disk. His newly entered information will readily infect the disks of his colleagues (because the colleagues promiscuously insert their disks into one another's computers) and will spread like an epidemic around the circle. Thimbleby's liveware is not entirely virus-like: it could not spread to just anybody's computer and do damage. It spreads data only to already-existing copies of its own database; and you will not be infected by liveware unless you positively opt for infection.

Incidentally, Thimbleby, who is much concerned with the virus menace, points out that you can gain some protection by using computer systems that other people don't use. The usual justification for purchasing today's numerically dominant computer is simply and solely that it *is* numerically dominant. Almost every knowledgeable person agrees that, in terms of quality and especially user-friendliness, the rival, minority system is superior. Nevertheless, ubiquity is held to be good in itself, sufficient to outweigh sheer quality. Buy the same (albeit inferior) computer as your colleagues, the argument goes, and you'll be able to benefit from shared software, and from a generally large circulation of available software. The irony is that, with the advent of the virus plague, ``benefit'' is not all that you are likely to get. Not only should we all be very hesitant before we accept a disk from a colleague. We should also be aware that, if we join a large community of users of a particular make of computer, we are also joining a large community of viruses --- even, it turns out, *disproportionately* larger.

Returning to possible uses of viruses for positive purposes, there are proposals to exploit the ``poacher turned gamekeeper'' principle, and ``set a thief to catch a thief.'' A simple way would be to take any of the existing anti-viral programs and load it, as a ``warhead,'' into a harmless self-replicating virus. From a ``public health'' point of view, a spreading epidemic of anti-viral software could be especially beneficial because the computers most vulnerable to malicious viruses --- those whose owners are promiscuous in the exchange of pirated programs --- will also be most vulnerable to infection by the healing anti-virus. A more penetrating anti-virus might --- as in the immune system --- ``learn'' or ``evolve'' an improved capacity to attack whatever viruses it encountered.

I can imagine other uses of the computer virus principle which, if not exactly altruistic, are at least constructive enough to escape the charge of pure vandalism. A computer company might wish to do market research on the habits of its customers, with a view to improving the design of future products. Do users like to choose files by pictorial icon, or do they opt to display them by textual name only? How deeply do people nest folders (directories) within one another? Do people settle down for a long session with only one program, say a word processors, or are they constantly switching back and forth, say between writing and drawing programs? Do people succeed in moving the mouse pointer straight to the target, or do they meander around in time-wasting hunting movements that could be rectified by a change in design?

The company could send out a questionnaire asking all these questions, but the customers that replied would be a biased sample and, in any case, their own assessment of their computer-using behavior might be inaccurate. A better solution would be a market-research computer program. Customers would be asked to load this program into their system where it would unobtrusively sit, quietly monitoring and tallying key-presses and mouse movements. At the end of a year, the customer would be asked to send in the disk file containing all the tallyings of the market-research program. But again, most people would not bother to cooperate and some might see it as an invasion of privacy and of their disk space.

The perfect solution, from the company's point of view, would be a virus. Like any other virus, it would be self-replicating and secretive. But it would not be destructive or facetious like an ordinary virus. Along with its self-replicating booster it would contain a market-research warhead. The virus would be released surreptitiously into the community of computer users. Just like an ordinary virus it would spread around, as people passed floppy disks and e-mail around the community. As the virus spread from computer to computer, it would build up statistics on users behavior, monitored secretly from deep within a succession of systems. Every now and again, a copy of the viruses would happen to find its way, by normal epidemic traffic, back into one of the company's own computers. There it would be debriefed and its data collated with data from other copies of the virus that had come ``home."

Looking into the future, it is not fanciful to imagine a time when viruses, both bad and good, have become so ubiquitous that we could speak of an ecological community of viruses and legitimate programs coexisting in the silicosphere. At present, software is advertised as, say, ``Compatible with System 7." In the future, products may be advertised as ``Compatible with all viruses registered in the 1998 World Virus Census; immune to all listed virulent viruses; takes full advantage of the facilities offered by the following benign viruses if present..." Word-processing software, say, may hand over particular functions, such as word-counting and string-searches, to friendly viruses burrowing autonomously through the text.

Looking even further into the future, whole integrated software systems might grow, not by design, but by something like the growth of an ecological community such as a tropical rain-forest. Gangs of mutually compatible viruses might grow up, in the same way as genomes can be regarded as gangs of mutually compatible genes (Dawkins, 1982). Indeed, I have even suggested that our genomes should be regarded as gigantic colonies of viruses (Dawkins, 1976). Genes cooperate with one another in genomes because natural selection has favored those genes that prosper in the presence of the other genes that happen to be common in the gene pool. Different gene pools may evolve towards different combinations of mutually compatible genes. I envisage a time when, in the same kind of way, computer viruses may evolve towards compatibility with other viruses, to form communities or gangs. But then again, perhaps not! At any rate, I find the speculation more alarming than exciting.

At present, computer viruses don't strictly evolve. They are invented by human programmers, and if they evolve they do so in the same weak sense as cars or aeroplanes evolve. Designers derive this year's car as a slight modification of last year's car, and then may, more or less consciously, continue a trend of the last few years --- further flattening of the radiator grill or whatever it may be. Computer virus designers dream up ever more devious tricks for outwitting the programmers of anti-virus software. But computer viruses don't --- so far --- mutate and evolve by true natural selection. They may do so in the future. Whether they evolve by natural selection, or whether their evolution is steered by human designers, may not make much difference to their eventual performance. By either kind of evolution, we expect them to become better at concealment, and we expect them to become subtly compatible with other viruses that are at the same time prospering in the computer community.

DNA viruses and computer viruses spread for the same reason: an environment exists in which there is machinery well set up to duplicate and spread them around and to obey the instructions that the viruses embody. These two environments are, respectively, the environment of cellular physiology and the environment provided by a large community of computers and data-handling machinery. Are there any other environments like these, any other humming paradises of replication?

3 The Infected Mind

I have already alluded to the programmed-in gullibility of a child, so useful for learning language and traditional wisdom, and so easily subverted by nuns, Moonies and their ilk. More generally, we all exchange information with one another. We don't exactly plug floppy disks into slots in one another's skulls, but we exchange sentences, both through our ears and through our eyes. We notice each other's styles of moving and dressing and are influenced. We take in advertising jingles, and are presumably persuaded by them, otherwise hard-headed businessmen would not spend so much money polluting their air with them.

Think about the two qualities that a virus, or any sort of parasitic replicator, demands of a friendly medium,. the two qualities that make cellular machinery so friendly towards parasitic DNA, and that make computers so friendly towards computer viruses. These qualities are, firstly, a readiness to replicate information accurately, perhaps with some mistakes that are subsequently reproduced accurately; and, secondly, a readiness to obey instructions encoded in the information so replicated.

Cellular machinery and electronic computers excel in both these virus-friendly qualities. How do human brains match up? As faithful duplicators, they are certainly less perfect than either cells or electronic computers. Nevertheless, they are still pretty good, perhaps about as faithful as an RNA virus, though not as good as DNA with all its elaborate proofreading measures against textual degradation. Evidence of the fidelity of brains, especially child brains, as data duplicators is provided by language itself. Shaw's Professor Higgins was able by ear alone to place Londoners in the street where they grew up. Fiction is not evidence for anything, but everyone knows that Higgins's fictional skill is only an exaggeration of something we can all down. Any American can tell Deep South from Mid West, New England from Hillbilly. Any New Yorker can tell Bronx from Brooklyn. Equivalent claims could be substantiated for any country. What this phenomenon means is that human brains are capable of pretty accurate copying (otherwise the accents of, say, Newcastle would not be stable enough to be recognized) but with some mistakes (otherwise pronunciation would not evolve, and all speakers of a language would inherit identically the same accents from their remote ancestors). Language evolves, because it has both the great stability and the slight changeability that are prerequisites for any evolving system.

The second requirement of a virus-friendly environment --- that it should obey a program of coded instructions --- is again only quantitatively less true for brains than for cells or computers. We sometimes obey orders from one another, but also we sometimes don't. Nevertheless, it is a telling fact that, the world over, the vast majority of children follow the religion of their parents rather than any of the other available religions. Instructions to genuflect, to bow towards Mecca, to nod one's head rhythmically towards the wall, to shake like a maniac, to ``speak in tongues'' --- the list of such arbitrary and pointless motor patterns offered by religion alone is extensive --- are obeyed, if not slavishly, at least with some reasonably high statistical probability.

Less portentously, and again especially prominent in children, the ``craze'' is a striking example of behavior that owes more to epidemiology than to rational choice. Yo-yos, hula hoops and pogo sticks, with their associated behavioral fixed actions, sweep through schools, and more sporadically leap from school to school, in patterns that differ from a measles epidemic in no serious particular. Ten years ago, you could have traveled thousands of miles through the United States and never seen a baseball cap turned back to front. Today, the reverse baseball cap is ubiquitous. I do not know what the pattern of geographical spread of the reverse baseball cap precisely was, but epidemiology is certainly among the professions primarily qualified to study it. We don't have to get into arguments about ``determinism''; we don't have to claim that children are compelled to imitate their

fellows' hat fashions. It is enough that their hat-wearing behavior, as a matter of fact, *is* statistically affected by the hat-wearing behavior of their fellows.

Trivial though they are, crazes provide us with yet more circumstantial evidence that human minds, especially perhaps juvenile ones, have the qualities that we have singled out as desirable for an informational parasite. At the very least the mind is a plausible *candidate* for infection by something like a computer virus, even if it is not quite such a parasite's dream-environment as a cell nucleus or an electronic computer.

It is intriguing to wonder what it might feel like, from the inside, if one's mind were the victim of a ``virus." This might be a deliberately designed parasite, like a present-day computer virus. Or it might be an inadvertently mutated and unconsciously evolved parasite. Either way, especially if the evolved parasite was the memic descendant of a long line of successful ancestors, we are entitled to expect the typical ``mind virus" to be pretty good at its job of getting itself successfully replicated.

Progressive evolution of more effective mind-parasites will have two aspects. New ``mutants" (either random or designed by humans) that are better at spreading will become more numerous. And there will be a ganging up of ideas that flourish in one another's presence, ideas that mutually support one another just as genes do and as I have speculated computer viruses may one day do. We expect that replicators will go around together from brain to brain in mutually compatible gangs. These gangs will come to constitute a package, which may be sufficiently stable to deserve a collective name such as Roman Catholicism or Voodoo. It doesn't too much matter whether we analogize the whole package to a single virus, to each one of the component parts to a single virus. The analogy is not that precise anyway, just as the distinction between a computer virus and a computer worm is nothing to get worked up about. What matters is that minds are friendly environments to parasitic, self-replicating ideas or information, and that minds are typically massively infected.

Like computer viruses, successful mind viruses will tend to be hard for their victims to detect. If you are the victim of one, the chances are that you won't know it, and may even vigorously deny it. Accepting that a virus might be difficult to detect in your own mind, what tell-tale signs might you look out for? I shall answer by imaging how a medical textbook might describe the typical symptoms of a sufferer (arbitrarily assumed to be male).

1. The patient typically finds himself impelled by some deep, inner conviction that something is true, or right, or virtuous: a conviction that doesn't seem to owe anything to evidence or reason, but which, nevertheless, he feels as totally compelling and convincing. We doctors refer to such a belief as ``faith."

2. Patients typically make a positive virtue of faith's being strong and unshakable, *in spite of* not being based upon evidence. Indeed, they may fell that the less evidence there is, the more virtuous the belief (see below).

This paradoxical idea that lack of evidence is a positive virtue where faith is concerned has something of the quality of a program that is self-sustaining, because it is self-referential (see the chapter ``On Viral Sentences and Self-Replicating Structures" in Hofstadter, 1985). Once the proposition is believed, it automatically undermines opposition to itself. The ``lack of evidence is a virtue" idea could be an admirable sidekick, ganging up with faith itself in a clique of mutually supportive viral programs.

3. A related symptom, which a faith-sufferer may also present, is the conviction that ``mystery," *per*

se, is a good thing. It is not a virtue to solve mysteries. Rather we should enjoy them, even revel in their insolubility.

Any impulse to solve mysteries could be serious inimical to the spread of a mind virus. It would not, therefore, be surprising if the idea that ``mysteries are better not solved'' was a favored member of a mutually supporting gang of viruses. Take the ``Mystery of Transubstantiation.'' It is easy and non-mysterious to believe that in some symbolic or metaphorical sense the eucharistic wine turns into the blood of Christ. The Roman Catholic doctrine of transubstantiation, however, claims far more. The ``whole substance'' of the wine is converted into the blood of Christ; the appearance of wine that remains is ``merely accidental,'' ``inhering in no substance'' (Kenny, 1986, p. 72). Transubstantiation is colloquially taught as meaning that the wine ``literally'' turns into the blood of Christ. Whether in its obfuscatory Aristotelian or its franker colloquial form, the claim of transubstantiation can be made only if we do serious violence to the normal meanings of words like ``substance'' and ``literally.'' Redefining words is not a sin, but, if we use words like ``whole substance'' and ``literally'' for this case, what word are we going to use when we really and truly *want* to say that something did actually happen? As Anthony Kenny observed of his own puzzlement as a young seminarian, ``For all I could tell, my typewriter might be Benjamin Disraeli transubstantiated....''

Roman Catholics, whose belief in infallible authority compels them to accept that wine becomes physically transformed into blood despite all appearances, refer to the ``mystery'' of transubstantiation. Calling it a mystery makes everything OK, you see. At least, it works for a mind well prepared by background infection. Exactly the same trick is performed in the ``mystery'' of the Trinity. Mysteries are not meant to be solved, they are meant to strike awe. The ``mystery is a virtue'' idea comes to the aid of the Catholic, who would otherwise find intolerable the obligation to believe the obvious nonsense of the transubstantiation and the ``three-in-one.'' Again, the belief that ``mystery is a virtue'' has a self-referential ring. As Hofstadter might put it, the very mysteriousness of the belief moves the believer to perpetuate the mystery.

An extreme symptom of ``mystery is a virtue'' infection is Tertullian's ``*Certum est quia impossibile est*'' (It is certain because it is impossible''). That way madness lies. One is tempted to quote Lewis Carroll's White Queen, who, in response to Alice's ``One can't believe impossible things'' retorted ``I daresay you haven't had much practice... When I was your age, I always did it for half-an-hour a day. Why, sometimes I've believed as many as six impossible things before breakfast.'' Or Douglas Adam's Electric Monk, a labor-saving device programmed to do your believing for you, which was capable of ``believing things they'd have difficulty believing in Salt Lake City'' and which, at the moment of being introduced to the reader, believed, contrary to all the evidence, that everything in the world was a uniform shade of pink. But White Queens and Electric Monks become less funny when you realize that these virtuoso believers are indistinguishable from revered theologians in real life. ``It is by all means to be believed, because it is absurd'' (Tertullian again). Sir Thomas Browne (1635) quotes Tertullian with approval, and goes further: ``Methinks there be not impossibilities enough in religion for an active faith.'' And ``I desire to exercise my faith in the difficultest point; for to credit ordinary and visible objects is not faith, but perswasion [sic].''

I have the feeling that something more interesting is going on here than just plain insanity or surrealist nonsense, something akin to the admiration we feel when we watch a ten-ball juggler on a tightrope. It is as though the faithful gain prestige through managing to believe even more impossible things than their rivals succeed in believing. Are these people testing --- exercising --- their believing muscles, training themselves to believe impossible things so that they can take in their stride the merely improbable things that they are ordinarily called upon to believe?

While I was writing this, the *Guardian* (July 29, 1991) fortuitously carried a beautiful example. It came in an interview with a rabbi undertaking the bizarre task of vetting the kosher-purity of food products right back to the ultimate origins of their minutest ingredients. He was currently agonizing over whether to go all the way to China to scrutinize the menthol that goes into cough sweets. ``Have you ever tried checking Chinese menthol... it was extremely difficult, especially since the first letter we sent received the reply in best Chinese English, `The product contains no kosher'... China has only recently started opening up to kosher investigators. The menthol should be OK, but you can never be absolutely sure unless you visit." These kosher investigators run a telephone hot-line on which up-to-the-minute red-alerts of suspicion are recorded against chocolate bars and cod-liver oil. The rabbi sighs that the green-inspired trend away from artificial colors and flavors ``makes life miserable in the kosher field because you have to follow all these things back." When the interviewer asks him why he bothers with this obviously pointless exercise, he makes it very clear that the point is precisely that there *is* no point:

> That most of the Kashrut laws are divine ordinances without reason given is 100 per cent the point. It is very easy not to murder people. Very easy. It is a little bit harder not to steal because one is tempted occasionally. So that is no great proof that I believe in God or am fulfilling His will. But, if He tells me not to have a cup of coffee with milk in it with my mincemeat and peaces at lunchtime, that is a test. The only reason I am doing that is because I have been told to so do. It is something difficult.

Helena Cronin has suggested to me that there may be an analogy here to Zahavi's handicap theory of sexual selection and the evolution of signals (Zahavi, 1975). Long unfashionable, even ridiculed (Dawkins, 1976), Zahavi's theory has recently been cleverly rehabilitated (Grafen, 1990 a, b) and is now taken seriously by evolutionary biologists (Dawkins, 1989). Zahavi suggests that peacocks, for instance, evolve their absurdly burdensome fans with their ridiculously conspicuous (to predators) colors, precisely *because* they are burdensome and dangerous, and therefore impressive to females. The peacock is, in effect, saying: ``Look how fit and strong I must be, since I can afford to carry around this preposterous tail."

To avoid misunderstanding of the subjective language in which Zahavi likes to make his points, I should add that the biologist's convention of personifying the unconscious actions of natural selection is taken for granted here. Grafen has translated the argument into an orthodox Darwinian mathematical model, and it works. No claim is here being made about the intentionality or awareness of peacocks and peahens. They can be as sphexish or as intentional as you please (Dennett, 1983, 1984). Moreover, Zahavi's theory is general enough not to depend upon a Darwinian underpinning. A flower advertising its nectar to a ``skeptical" bee could benefit from the Zahavi principle. But so could a human salesman seeking to impress a client.

The premise of Zahavi's idea is that natural selection will favor skepticism among females (or among recipients of advertising messages generally). The only way for a male (or any advertiser) to authenticate his boast of strength (quality, or whatever is is) is to prove that it is true by shouldering a truly costly handicap --- a handicap *that only a genuinely strong* (high quality, etc.) male could bear. It may be called the principle of costly authentication. And now to the point. Is it possible that some religious doctrines are favored not *in spite of* being ridiculous but precisely *because* they are ridiculous? Any wimp in religion could believe that bread *symbolically* represents the body of Christ, but it takes a real, red-blooded Catholic to believe something as daft as the transubstantiation. If you believe that you can believe anything, and (witness the story of Doubting Thomas) these people are trained to see that as a virtue.

Let us return to our list of symptoms that someone afflicted with the mental virus of faith, and its accompanying gang of secondary infections, may expect to experience.

4. The sufferer may find himself behaving intolerantly towards vectors of rival faiths, in extreme cases even killing them or advocating their deaths. He may be similarly violent in his disposition towards apostates (people who once held the faith but have renounced it); or towards heretics (people who espouse a different --- often, perhaps significantly, only very slightly different --- version of the faith). He may also feel hostile towards other modes of thought that are potentially inimical to his faith, such as the method of scientific reason which may function rather like a piece of anti-viral software.

The threat to kill the distinguished novelist Salman Rushdie is only the latest in a long line of sad examples. On the very day that I wrote this, the Japanese translator of *The Satanic Verses* was found murdered, a week after a near-fatal attack on the Italian translator of the same book. By the way, the apparently opposite symptom of ``sympathy'' for Muslim ``hurt,'' voiced by the Archbishop of Canterbury and other Christian leaders (verging, in the case of the Vatican, on outright criminal complicity) is, of course, a manifestation of the symptom we discussed earlier: the delusion that faith, however obnoxious its results, has to be respected simply because it *is* faith.

Murder is an extreme, of course. But there is an even more extreme symptom, and that is suicide in the militant service of a faith. Like a soldier ant programmed to sacrifice her life for germ-line copies of the genes that did the programming, a young Arab or Japanese [??!] is taught that to die in a holy war is the quickest way to heaven. Whether the leaders who exploit him really believe this does not diminish the brutal power that the ``suicide mission virus'' wields on behalf of the faith. Of course suicide, like murder, is a mixed blessing: would-be converts may be repelled, or may treat with contempt a faith that is perceived as insecure enough to need such tactics.

More obviously, if too many individuals sacrifice themselves the supply of believers could run low. This was true of a notorious example of faith-inspired suicide, though in this case it was not ``kamikaze'' death in battle. The Peoples' Temple sect became extinct when its leader, the Reverend Jim Jones, led the bulk of his followers from the United States to the Promised Land of ``Jonestown'' in the Guyanan jungle where he persuaded more than 900 of them, children first, to drink cyanide. The macabre affair was fully investigated by a team from the *San Francisco Chronicle* (Kilduff and Javers, 1978).

> Jones, ``the Father,'' had called his flock together and told them it was time to depart for heaven.
> ``We're going to meet,'' he promised, ``in another place.''
> The words kept coming over the camp's loudspeakers.
> ``There is great dignity in dying. It is a great demonstration for everyone to die.''

Incidentally, it does not escape the trained mind of the alert sociobiologist that Jones, within his sect in earlier days, ``proclaimed himself the only person permitted to have sex'' (presumably his partners were also permitted). ``A secretary would arrange for Jones's liaisons. She would call up and say, `Father hates to do this, but he has this tremendous urge and could you please...?' '' His victims were not only female. One 17-year-old male follower, from the days when Jones's community was still in San Francisco, told how he was taken for dirty weekends to a hotel where Jones received a ``minister's discount for Rev. Jim Jones and son.'' The same boy said: ``I was really in awe of him. He was more than a father. I would have killed my parents for him.'' What is remarkable about the Reverend Jim Jones is not his own self-serving behavior but the almost superhuman gullibility of his

followers. Given such prodigious credulity, can anyone doubt that human minds are ripe for malignant infection?

Admittedly, the Reverend Jones conned only a few thousand people. But his case is an extreme, the tip of an iceberg. The same eagerness to be conned by religious leaders is widespread. Most of us would have been prepared to bet that nobody could get away with going on television and saying, in all but so many words, ``Send me your money, so that I can use it to persuade other suckers to send me their money too." Yet today, in every major conurbation in the United States, you can find at least one television evangelist channel entirely devoted to this transparent confidence trick. And they get away with it in sackfuls. Faced with suckerdom on this awesome scale, it is hard not to feel a grudging sympathy with the shiny-suited conmen. Until you realize that not all the suckers are rich, and that it is often widows' mites on which the evangelists are growing fat. I have even heard one of them explicitly invoking the principle that I now identify with Zahavi's principle of costly authentication. God really appreciates a donation, he said with passionate sincerity, only when that donation is so large that it hurts. Elderly paupers were wheeled on to testify how much happier they felt since they had made over their little all to the Reverend whoever it was.

5. The patient may notice that the particular convictions that he holds, while having nothing to do with evidence, do seem to owe a great deal to epidemiology. Why, he may wonder, do I hold *this* set of convictions rather than *that* set? Is it because I surveyed all the world's faiths and chose the one whose claims seemed most convincing? Almost certainly not. If you have a faith, it is statistically overwhelmingly likely that it is the same faith as your parents and grandparents had. No doubt soaring cathedrals, stirring music, moving stories and parables, help a bit. But by far the most important variable determining your religion is the accident of birth. The convictions that you so passionately believe would have been a completely different, and largely contradictory, set of convictions, if only you had happened to be born in a different place. Epidemiology, not evidence.

6. If the patient is one of the rare exceptions who follows a different religion from his parents, the explanation may still be epidemiological. To be sure, it is *possible* that he dispassionately surveyed the world's faiths and chose the most convincing one. But it is statistically more probable that he has been exposed to a particularly potent infective agent --- a John Wesley, a Jim Jones or a St. Paul. Here we are talking about horizontal transmission, as in measles. Before, the epidemiology was that of vertical transmission, as in Huntington's Chorea.

7. The internal sensations of the patient may be startlingly reminiscent of those more ordinarily associated with sexual love. This is an extremely potent force in the brain, and it is not surprising that some viruses have evolved to exploit it. St. Teresa of Avila's famously orgasmic vision is too notorious to need quoting again. More seriously, and on a less crudely sensual plane, the philosophy Anthony Kenny provides moving testimony to the pure delight that awaits those that manage to believe in the mystery of transubstantiation. After describing his ordination as a Roman Catholic priest, empowered by laying on of hands to celebrate Mass, he goes on that he vividly recalls

> the exaltation of the first months during which I had the power to say Mass. Normally a slow and sluggish riser, I would leap early out of bed, fully awake and full of excitement at the thought of the momentous act I was privileged to perform. I rarely said the public Community Mass: most days I celebrated alone at a side altar with a junior member of the College to serve as acolyte and congregation. But that made no difference to the solemnity of the sacrifice or the validity of the consecration.
>
> It was touching the body of Christ, the closeness of the priest to Jesus, which most enthralled me. I would gaze on the Host after the words of consecration, soft-eyed like a lover looking

> into the eyes of his beloved... Those early days as a priest remain in my memory as days of fulfilment and tremulous happiness; something precious, and yet too fragile to last, like a romantic love-affair brought up short by the reality of an ill-assorted marriage. (Kenny, 1986, pp. 101-2)

Dr. Kenny is affectingly believable that it felt to him, as a young priest, as though he was in love with the consecrated host. What a brilliantly successful virus! On the same page, incidentally, Kenny also shows us that the virus is transmitted contagiously --- if not literally then at least in some sense --- from the palm of the infecting bishop's hand through the top of the new priest's head:

> If Catholic doctrine is true, every priest validly ordained derives his orders in an unbroken line of laying on of hands, through the bishop who ordains him, back to one of the twelve Apostles... there must be centuries-long, recorded chains of layings on of hands. It surprises me that priests never seem to trouble to trace their spiritual ancestry in this way, finding out who ordained their bishop, and who ordained him, and so on to Julius II or Celestine V or Hildebrand, or Gregory the Great, perhaps. (Kenny, 1986, p. 101)

It surprises me, too.

4 Is Science a Virus

No. Not unless all computer programs are viruses. Good, useful programs spread because people evaluate them, recommend them and pass them on. Computer viruses spread solely because they embody the coded instructions: ``Spread me." Scientific ideas, like all memes, are subject to a kind of natural selection, and this might look superficially virus-like. But the selective forces that scrutinize scientific ideas are not arbitrary and capricious. They are exacting, well-honed rules, and they do not favor pointless self-serving behavior. They favor all the virtues laid out in textbooks of standard methodology: testability, evidential support, precision, quantifiability, consistency, intersubjectivity, repeatability, universality, progressiveness, independence of cultural milieu, and so on. Faith spreads despite a total lack of every single one of these virtues.

You may find elements of epidemiology in the spread of scientific ideas, but it will be largely descriptive epidemiology. The rapid spread of a good idea through the scientific community may even look like a description of a measles epidemic. But when you examine the underlying reasons you find that they are good ones, satisfying the demanding standards of scientific method. In the history of the spread of faith you will find little else but epidemiology, and causal epidemiology at that. The reason why person A believes one thing and B believes another is simply and solely that A was born on one continent and B on another. Testability, evidential support and the rest aren't even remotely considered. For scientific belief, epidemiology merely comes along afterwards and describes the history of its acceptance. For religious belief, epidemiology is the root cause.

5 Epilogue

Happily, viruses don't win every time. Many children emerge unscathed from the worst that nuns and mullahs can throw at them. Anthony Kenny's own story has a happy ending. He eventually renounced his orders because he could no longer tolerate the obvious contradictions within Catholic belief, and he is now a highly respected scholar. But one cannot help remarking that it must be a powerful infection indeed that took a man of his wisdom and intelligence --- President of the British Academy, no less --- three decades to fight off. Am I unduly alarmist to fear for the soul of my six-year-old innocent?

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Cover

Finding Awe, Reverence, and Wonder in Science

By Kendrick Frazier

Book Review
Unweaving the Rainbow: Science, Delusion, and the Appetite for Wonder By Richard Dawkins Houghton Mifflin, Boston, 1998. ISBN 0-395-88382-2. 337 pp. Hardcover, $26.

Unweaving the Rainbow

The central challenge addressed in Richard Dawkins's *Unweaving the Rainbow* is the perception among many that science somehow diminishes our appreciation of the world. It is a problem all who attempt to explain science to the wider public must sometime face, and noted thinkers like Richard Feynman, Carl Sagan, and Martin Gardner all have written about it. In 1995, Dawkins, the noted Oxford zoologist and evolutionist (and CSICOP Fellow), became the first Charles Simonyi professor of the public understanding of science at Oxford. In this book he faces these wider issues, which go far beyond evolutionary biology but are still enriched and informed by Dawkins's intimate familiarity with that subject. His title is from Keats, who believed that Newton had destroyed all the poetry of the rainbow by reducing it to its prismatic colors.

Dawkins quickly lays that particular complaint to rest by showing how Newton's optics led to spectroscopy which led to measurement of emission and absorption line spectra and thereby to direct understanding of the nature and characteristics

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of stars-their size, luminosity, history, and future ("Barcodes of the Stars")-and then to our wider understanding of the cosmos.

"Newton's dissection of the rainbow into light of different wavelengths led onto Maxwell's theory of electromagnetism and thence to Einstein's theory of special relativity," notes Dawkins, adding: "If you think the rainbow has poetic mystery, you should try relativity." All from a little "unweaving of the rainbow." And nothing about it need diminish our astonishment and appreciation of the beauty of a rainbow arcing across the rain-darkened sky.

The positive message throughout is that the impulses to awe, reverence, and wonder that led the poet William Blake to mysticism (and lesser figures to paranormal superstition) are "precisely those that lead others of us to science. Our interpretation is different but what excites us is the same." The scientist has the same wonder, the same sense of the profound, as the mystic, but with an additional impulse: let's find out what we can about it. (*Skeptical Inquirer* readers got a teaser of some of the book's arguments in Dawkins's article "Science, Delusion, and the Appetite for Wonder," March/April 1998.)

Dawkins argues that while poets might well seek inspiration from science, science should reach out to wider constituencies among poets, artists, and all others who share some of the same impulses.

He doesn't argue that scientists should attempt to write poetically, unless like Sagan or Loren Eiseley they have unique skills in that area. Simple clarity will do. Says Dawkins: "The poetry is in the science."

Along the way, Dawkins examines superstition and gullibility, lamenting how people can find the "meaningless pap" of astrology appealing, in the face of the real universe as revealed by astronomy. He suggests that grouping people according to which of only 12 mythic signs they were born under is "a form of discriminatory labeling rather like the cultural stereotypes that many of us nowadays find objectionable." He regrets that we are "in the grip of a near epidemic of paranormal propaganda on television." He recalls Arthur C. Clarke's Third Law, "that any sufficiently advanced technology is indistinguishable from magic," and thoughtfully considers, "How are we to know when skepticism is justified, and when it is dogmatic, intolerant short-sightedness?" He refers to a "spectrum of improbabilities" and suggests ways to think about how to evaluate an amazing or miraculous story.

Abetted by the media, astrology, paranormalism, and alien visitations have an inside track on the public consciousness, Dawkins notes, but there may be paradoxical grounds for encouragement in the realization that at least some of this tendency exploits "our natural and laudable appetite for wonder." This wonder, given proper access, can be fulfilled just as well by science and the real wonders of nature.

In one chapter, "Unweaving the Uncanny," Dawkins shows how to "take the sting out of seemingly astonishing coincidence by quietly sitting down and calculating the likelihood that it would have happened anyway." He invents a term he calls PETWHAC, for *Population of Events That Would Have Appeared Coincidental*, useful in evaluating how probable improbable-seeming events actually are, liberating us from a need to invoke occult forces. He offers a number of fresh examples, such as when his wife bought her mother an antique watch and she got it home and peeled off the label to find revealed her mother's initials, "M.A.B." "Uncanny?" Dawkins asks. He does the calculation based on frequencies of names in phone directories and finds that if everyone in Britain bought an antique engraved watch, 3,000 of them would find their mother's initials on it.

The Blind Watchmaker

Seeking to understand how we are so strongly impressed by coincidences, Dawkins turns to his Darwinian roots. Like all other creatures, humans must behave as intuitive statisticians. We need to steer between false positive and false negative errors according to which offer the greater penalty in a given situation. Furthermore, our willingness to be impressed by uncanny coincidence was influenced by the smaller population size of our ancestors and the relative sameness of their everyday experience, leading us to expect a very modest level of coincidence. Yet today we are immersed in a giant global media culture and our access to stories of all kind is multiplied many times compared with that of our small-village ancestors. This means, says Dawkins, that the number of opportunities for coincidence is greater for each one of us than it would have been for our ancestors, and consequently greater than our brains are calibrated to assess. Theoretically, we can learn to recalibrate ourselves, but that is "revealingly difficult even for sophisticated scientists and mathematicians."

There is much else in Dawkins's purview. He writes about DNA fingerprinting (a bit hard-going, I must admit). He offers chapters on not just good poetic science, where helpful analogies and metaphors stimulate the imagination, but also on the danger of "bad poetic science," the power of poetic imagery to inspire bad science, even if it is good poetry. Included here are Teilhard de Chardin's "euphoristic prose poetry" and also the notorious fondness of mystics for "energy" and "vibrations," technical terms creating the illusion of scientific content where there is no content of any kind. Quantum uncertainty has provoked its share of bad poetic science too, as has the postmodernist movement in academia and even, surprisingly, Dawkins's own field of evolutionary theory. Dawkins considers his own concept of the "selfish gene" good poetic science that aids understanding rather than impedes it but says it is susceptible to being misunderstood by bad poetic science.

The Selfish Gene

Another chapter describes how there is a sense in which our DNA is a coded description of the worlds in which our ancestors survived. "And isn't it an arresting thought?" Dawkins asks. "We are digital archives of the African Pliocene, even of Devonian seas; walking repositories of wisdom out of the old days. You could spend a lifetime reading in this ancient library and die unsated by the wonder of it." In a related sense, the brain of an individual houses a parallel set of models of the animal's own world.

The final chapters deal with the wonderful machinery of perception. One example is how the nerve cells economize by registering only changes from moment to moment and ignoring the more common stasis-all the boring stuff. Computers are poor at recognizing patterns such as faces, but humans, through evolution, have become superb at these and other pattern-recognition abilities. We usually create fairly accurate models of the world but can also create illusions and concoct hallucinations when something goes just slightly awry. "A brain that is good at simulating models in imagination is also, almost inevitably, in danger of self-delusion," Dawkins warns. When we see visions of angels, saints, or gods, they seem real because they must; they are models put together by the normal simulation software in the brain using the same modeling techniques that it ordinarily uses when presenting its continuously updated edition of reality.

Dawkins is one of the treasured few scientists today writing in depth about science and scientific processes for intelligent general readers whose works are simultaneously scientifically rich and provocative, accessible (although there is never a sense of being watered down), and successful. He brings a discerning critical intelligence and an impassioned concern in the hope that we will find science worthy of our own awe. At the same time by learning about our own genetic and environmental heritage and the workings of our brains we can learn how to be aware of our own capacities for self-delusion.

About the Reviewer

Kendrick Frazier is Editor of the *Skeptical Inquirer*.

Related Information

- *Unweaving the Rainbow: Science, Delusion, and the Appetite for Wonder*
- Other books by Richard Dawkins:
    - *The Selfish Gene*
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Snake Oil and Holy Water
Richard Dawkins, Forbes ASAP, 10.04.99

Are science and religion converging? No.

There are modern scientists whose words sound religious but whose beliefs, on close examination, turn out to be identical to those of other scientists who call themselves atheists. Ursula Goodenough's lyrical book, The Sacred Depths of Nature, is sold as a religious book, is endorsed by theologians on the back cover, and its chapters are liberally laced with prayers and devotional meditations.

Yet, by the book's own account, Goodenough does not believe in any sort of supreme being, does not believe in any sort of life after death. By any normal understanding of the English language, she is no more religious than I am. She shares with other atheistic scientists a feeling of awe at the majesty of the universe and the intricate complexity of life. Indeed, the jacket copy for her book--the message that science does not "point to an existence that is bleak, devoid of meaning, pointless," but on the contrary "can be a wellspring of solace and hope"--would have been equally suitable for my book, Unweaving the Rainbow, or Carl Sagan's Pale Blue Dot. If that is religion, then I am a deeply religious man. But it isn't. And I'm not. As far as I can tell, my "atheistic" views are identical to Ursula's "religious" ones. One of us is misusing the English language, and I don't think it's me.

Goodenough happens to be a biologist, but this kind of neo-Deistic pseudoreligion is more often associated with physicists. In Stephen Hawking's case, I hasten to insist, the accusation is unjust. His much-quotd phrase, "the mind of God," no more indicates belief in God than my saying, "God knows!" as a way of indicating that I don't. I suspect the same of Einstein invoking "dear Lord" to personify the laws of physics. Paul Davies, however, adopted Hawking's phrase as the title of a book that went on to earn the Templeton Prize for Progress in Religion, the most lucrative prize in the world today, prestigious enough to be presented in Westminster Abbey. The philosopher Daniel Dennett once remarked to me in Faustian vein: "Richard, if ever you fall on hard times..."

If you count Einstein and Hawking as religious, if you allow the cosmic awe of Goodenough, Davies, Sagan, and me as true religion, then religion and science have indeed merged, especially when you factor in such atheistic priests as Don Cupitt and many university chaplains. But if the term religion is allowed such a flabbily elastic definition, what word is left for conventional religion, religion as the ordinary person in the pew or on the prayer mat understands it today--indeed, as any intellectual would have understood it in previous centuries, when intellectuals were religious like everybody else?

If God is a synonym for the deepest principles of physics, what word is left for a hypothetical being who answers prayers, intervenes to save cancer patients or helps evolution over difficult jumps, forgives sins or dies for them? If we are allowed to relabel scientific awe as a religious impulse, the case goes through on the nod. You have redefined science as religion, so it's hardly surprising if they turn out to "converge."

Another kind of marriage has been alleged between modern physics and Eastern mysticism. The argument goes as follows: Quantum mechanics, that brilliantly successful flagship theory of modern science, is deeply mysterious and hard to understand. Eastern mystics have always been deeply mysterious and hard to understand. Therefore, Eastern mystics must have been talking about quantum theory all along.

Similar mileage is made of Heisenberg's uncertainty principle ("Aren't we all, in a very real sense, uncertain?"), fuzzy logic ("Yes, it's okay for you to be fuzzy, too"), chaos and complexity theory (the butterfly effect, the Platonic, hidden beauty of the Mandelbrot Set--you name it, somebody has mysticized it and turned it into dollars). You can buy any number of books on "quantum healing," not to mention quantum psychology, quantum responsibility, quantum morality, quantum immortality, and quantum theology. I haven't found a book on quantum feminism, quantum financial management, or Afro-quantum theory, but give it time.

The whole dippy business is ably exposed by the physicist Victor Stenger in his book, The Unconscious Quantum, from which the following gem is taken. In a lecture on "Afrocentric healing," the psychiatrist Patricia Newton said that traditional healers "are able to tap that other realm of negative entropy--that superquantum velocity and frequency of electromagnetic energy--and bring them as conduits down to our level. It's not magic. It's not mumbo jumbo. You will see the dawn of the 21st century, the new medical quantum physics really distributing these energies and what they are doing."

Sorry, but mumbo jumbo is precisely what it is. Not African mumbo jumbo but pseudoscientific mumbo jumbo, down to the trademark misuse of the word energy. It is also religion, masquerading as science in a cloying love feast of bogus convergence.

In 1996 the Vatican, fresh from its magnanimous reconciliation with Galileo, a mere 350 years after his death, publicly announced that evolution had been promoted from tentative hypothesis to accepted theory of science. This is less dramatic than many American Protestants think it is, for the Roman Catholic Church has never been noted for biblical literalism--on the contrary, it has treated the Bible with suspicion, as something close to a subversive document, needing to be carefully filtered through priests rather than given raw to congregations. The pope's recent message on evolution has, nevertheless, been hailed as another example of late-20th-century convergence between science and religion.

Responses to the pope's message exhibited liberal intellectuals at their worst, falling over themselves in their eagerness to concede to religion its own magisterium, of equal importance to that of science, but not opposed to it. Such agnostic conciliation is, once again, easy to mistake for a genuine meeting of minds.

At its most naive, this appeasement policy partitions the intellectual territory into "how questions" (science) and "why questions" (religion). What are "why questions," and why should we feel entitled to think they deserve an answer? There may be some deep questions about the cosmos that are forever beyond science. The mistake is to think that they are therefore not beyond religion, too.

I once asked a distinguished astronomer, a fellow of my college, to explain the big bang theory to me. He did so to the best of his (and my) ability, and I then asked what it was about the fundamental laws of physics that made the spontaneous origin of space and time possible. "Ah," he smiled, "now we move beyond the realm of science. This is where I have to hand you over to our good friend, the chaplain." But why the chaplain? Why not the gardener or the chef? Of course chaplains, unlike chefs and gardeners, claim to have some insight into ultimate questions. But what reason have we ever been given for taking their claims seriously? Once again, I suspect that my friend, the professor of astronomy, was using the Einstein/Hawking trick of letting "God" stand for "That which we don't understand." It would be a harmless trick if it were not continually misunderstood by those hungry to misunderstand it. In any case, optimists among scientists, of whom I am one, will insist, "That which we don't understand" means only "That which we don't yet understand." Science is still working on the problem. We don't know where, or even whether, we ultimately shall be brought up short.

Agnostic conciliation, which is the decent liberal bending over backward to concede as much as possible to anybody who shouts loud enough, reaches ludicrous lengths in the following common piece of sloppy thinking. It goes roughly like this: You can't prove a negative (so far so good). Science has no way to disprove the existence of a supreme being (this is strictly true). Therefore, belief or disbelief in a supreme being is a matter of pure, individual inclination, and both are therefore equally deserving of respectful attention! When you say it like that, the fallacy is almost self-evident; we hardly need spell out the reductio ad absurdum. As my colleague, the physical chemist Peter Atkins, puts it, we must be equally agnostic about the theory that there is a teapot in orbit around the planet Pluto. We can't disprove it. But that doesn't mean the theory that there is a teapot is on level terms with the theory that there isn't.

Now, if it be retorted that there actually are reasons X, Y, and Z for finding a supreme being more plausible than a teapot, then X, Y, and Z should be spelled out--because, if legitimate, they are proper scientific arguments that should be evaluated. Don't protect them from scrutiny behind a screen of agnostic tolerance. If religious arguments are actually better than Atkins' teapot theory, let us hear the case. Otherwise, let those who call themselves agnostic with respect to religion add that they are equally agnostic about orbiting teapots. At the same time, modern theists might acknowledge that, when it comes to Baal and the golden calf, Thor and Wotan, Poseidon and Apollo, Mithras and Ammon Ra, they are actually atheists. We are all atheists about most of the gods that humanity has ever believed in. Some of us just go one god further.

In any case, the belief that religion and science occupy separate magisteria is dishonest. It founders on the undeniable fact that religions still make claims about the world that on analysis turn out to be scientific claims. Moreover, religious apologists try to have it both ways. When talking to intellectuals, they carefully keep off science's turf, safe inside the separate and invulnerable religious magisterium. But when talking to a nonintellectual mass audience, they make wanton use of miracle stories--which are blatant intrusions into scientific territory.

The Virgin Birth, the Resurrection, the raising of Lazarus, even the Old Testament miracles, all are freely used for religious propaganda, and they are very effective with an audience of unsophisticates and children. Every one of these miracles amounts to a violation of the normal running of the natural world. Theologians should make a choice. You can claim your own magisterium, separate from science's but still deserving of respect. But in that case, you must renounce miracles. Or you can keep your Lourdes and your miracles and enjoy their huge recruiting potential among the uneducated. But then you must kiss goodbye to separate magisteria and your high-minded aspiration to converge with science.

The desire to have it both ways is not surprising in a good propagandist. What is surprising is the readiness of liberal agnostics to go along with it, and their readiness to write off, as simplistic, insensitive extremists, those of us with the temerity to blow the whistle. The whistle-blowers are accused of imagining an outdated caricature of religion in which God has a long white beard and lives in a physical place called heaven. Nowadays, we are told, religion has moved on. Heaven is not a physical place, and God does not have a physical body where a beard might sit. Well, yes, admirable: separate magisteria, real convergence. But the doctrine of the Assumption was defined as an Article of Faith by Pope Pius XII as recently as November 1, 1950, and is binding on all

Catholics. It clearly states that the body of Mary was taken into heaven and reunited with her soul. What can that mean, if not that heaven is a physical place containing bodies? To repeat, this is not a quaint and obsolete tradition with just a purely symbolic significance. It has officially, and recently, been declared to be literally true.

Convergence? Only when it suits. To an honest judge, the alleged marriage between religion and science is a shallow, empty, spin-doctored sham.

Richard Dawkins is a professor at Oxford University. His books include The Selfish Gene and, most recently, Unweaving the Rainbow.

Darwin and Darwinism

Richard Dawkins

To most people through history it has always seemed obvious that the teeming diversity of life, the uncanny perfection with which living organisms are equipped to survive and multiply, and the bewildering complexity of living machinery, can only have come about through divine creation. Yet repeatedly it has occurred to isolated thinkers that there might be an alternative to supernatural creation. the notion of species changing into other species was in the air, like so many other good ideas, in ancient Greece. It went into eclipse until the 18th century, when it resurfaced in the minds of such advanced thinkers as Pierre de Maupertuis, Erasmus Darwin and the man who styled himself the Chevalier de Lamarck. In the first half of the 19th century the idea became not uncommon in intellectual circles, especially geological ones, but always in a rather vague form and without any clear picture of the mechanism by which change might come about. It was Charles Darwin (Erasmus's grandson) who, spurred into print by Alfred Russel Wallace's independent discovery of his principle of natural selection, finally established the theory of evolution by the publication, in 1859, of the famous book whose title is usually abbreviated to the Origin of Species.

We should distinguish two quite distinct parts of Darwin's contribution. He amassed an overwhelming quantity of evidence for the fact that evolution has occurred, and, together with Wallace (independently) he thought up the only known workable theory of the reason why it leads to adaptive improvement - natural selection. Some fossil evidence was known to Darwin but he made more use of other evidence, less direct but in many ways more convincing, for the fact that evolution had taken place. the rapid alteration of animals and plants under domestication was persuasive evidence both for the fact that evolutionary change was possible and for the effectiveness of the artificial equivalent of natural selection. Darwin was particularly persuaded by the evidence from the geographical dispersion of animals. the presence of local island races, for example, is easily explicable by the evolution theory: the creation theory could explain them only by unparsimoniously assuming numerous 'foci of creation' dotted around the earth's surface. the hierarchical classification into which animals and plants fall so naturally is strongly suggestive of a family tree: the creation theory had to make contrived and elaborate assumptions about the creator's mind running along themes and variations. Darwin also used as evidence for his theory the fact that some organs seen in adults and embryos appear to be vestigial. According to the evolution theory such organs as the tiny buried hind-limb bones of whales are remnants of the walking legs of their terrestrial ancestors. In general the evidence for the fact that evolution has occurred consists of an enormous number of detailed observations which all make sense if we assume the theory of evolution, but which can be explained by the creation theory only if we assume that the creator elaborately set out to deceive us. Modern molecular evidence has boosted the evidence for evolution beyond Darwin's wildest dreams, and the fact of evolution is now as securely attested as any in science.

Turning from the fact of evolution to the less secure theory of its mechanism, natural selection, the mechanism that Darwin and Wallace suggested, amounts to the nonrandom survival of randomly varying hereditary characteristics. Other British Victorians, such as Patrick Matthew and Edward Blyth, had suggested something like it before, but they apparently saw it as a negative force only. Darwin and Wallace seem to have been the first to realise its full potential as a positive force guiding the evolution of all life in adaptive directions. Most previous evolutionists, such as Darwin's grandfather Erasmus, had inclined towards an alternative theory of the mechanism of evolution, now usually associated with Lamarck's name. This was the theory that improvements acquired during an organism's lifetime, such as the growth of organs during use and their shrinkage during disuse, were inherited. This theory of the inheritance of acquired characteristics has emotional appeal (for example to George Bernard Shaw in his Preface to Back to Methuselah) but the evidence does not support it. Nor is it theoretically plausible. In Darwin's time the matter was more in doubt, and Darwin himself flirted with a personalised version of Lamarckism when his natural selection theory ran into a difficulty.

That difficulty arose from current views of the nature of heredity. In the 19th century it was almost universally assumed that heredity was a blending process. On this blending inheritance theory, not only are offspring intermediate between their two parents in character and appearance, but the hereditary factors that they pass on to their own children are themselves inextricably merged. It can be shown that, if heredity is of this blending type, it is almost impossible for Darwinian natural selection to work because the available variation is halved in every generation. Darwin knew this, and it worried him enough to drive him in the direction of Lamarckism. It may also have contributed to the odd fact that Darwinism suffered a temporary spell of unfashionableness in the early part of the 20th century. the solution to the problem which so worried Darwin lay in Gregor Mendel's theory of particular inheritance, published in 1865 but unfortunately unread by Darwin, or practically anyone else until after Darwin's death.

Mendel's research, rediscovered at the turn of the century, demonstrated, what Darwin himself had at one time dimly glimpsed, that heredity is particulate, not blending. Whether or not offspring are bodily intermediate between their two parents, they inherit, and pass on, discrete hereditary particles - nowadays we call them genes. An individual either definitely inherits a particular gene from a particular parent or it definitely does not. Since the same can be said of its parents, it follows that an individual either inherits a particular gene from a particular grandparent or it does not. Every one of your genes comes from a particular one of your grandparents and, before that, from a particular one of your great grandparents. This argument can be applied repeatedly for an indefinite number of generations. Discrete single genes are shuffled independently through the generations like cards in a pack, rather than being mixed like the ingredients of a pudding.

This makes all the difference to the mathematical plausibility of the theory of natural selection. If heredity is particulate, natural selection really can work. As was first realised by the British mathematician G H Hardy and the German scientist W Weinberg, there is no inherent tendency for genes to disappear from the gene pool.

If they do disappear, it will be because of bad luck, or because of natural selection - because something about those genes influences the probability that individuals possessing them will survive and reproduce. the modern version of Darwinism, often called Neodarwinism, is based upon this insight. It was worked out in the 1920s and 1930s by the population geneticists R A Fisher, J B S Haldane and Sewall Wright, and later consolidated into the synthesis of the 1940s known as Neodarwinism. the recent revolution in molecular biology, beginning in the 1950s, has reinforced and confirmed, rather than changed, the synthetic theory of the 1930s and 40s.

the modern genetic theory of natural selection can be summarised as follows. the genes of a population of sexually interbreeding animals or plants constitute a gene pool. the genes compete in the gene pool in something like the same way as the early replicating molecules competed in the primeval soup. In practice genes in the gene pool spend their time either sitting in individual bodies which they helped to build, or travelling from body to body via sperm or egg in the process of sexual reproduction. Sexual reproduction keeps the genes shuffled, and it is in this sense that the long-term habitat of a gene is the gene pool. Any given gene originates in the gene pool as a result of a mutation, a random error in the gene-copying process. Once a new mutation has been formed, it can spread through the gene pool by means of sexual mixing. Mutation is the ultimate origin of genetic variation. Sexual reproduction, and genetic recombination due to crossing over see to it that genetic variation is rapidly distributed and recombined in the gene pool.

Any given gene in a gene pool is likely to exist in the form of several duplicate copies, either all descended from the same original mutant, or descended from independent parallel mutants. therefore each gene can be said to have a frequency in the gene pool. Some genes, such as the albino gene, are rare in the gene pool, others are common. At the genetic level, evolution may be defined as the process by which gene-frequencies change in gene pools.

there are various reasons why gene-frequencies might change: immigration, emigration, random drift, and natural selection. Immigration, emigration, and random drift are not of much interest from the point of view of adaptation, although they may be quite important in practice. It is natural selection which accounts for the perfection of adaptation, for the complex functional organisation of life, and for such progressive qualities as evolution may (controversially) exhibit. Genes in bodies exert an influence on the development of those bodies. Some bodies are better at surviving and reproducing than others. Good bodies, i.e. bodies that are good at surviving and reproducing, will tend to contribute more genes to the gene pools of the future than bodies that are bad at surviving and reproducing: genes that tend to make good bodies will come to predominate in gene pools. Natural selection is the differential survival and differential reproductive success of bodies: it is important because of its consequences for the differential survival of genes in gene pools.

Not all selective deaths lead to evolutionary change. On the contrary, much natural selection is so-called stabilising selection, removing genes from the gene pool that tend to cause deviation from an already optimal form. But when environmental conditions change, either through natural catastrophe or through evolutionary improvement of other creatures (predators, prey, parasites, and so on), selection may lead to evolutionary change.

Evolution under the influence of natural selection leads to adaptive improvement. Evolution, whether under the influence of natural selection or not, leads to divergence and diversity. From a single ultimate ancestor, many hundreds of millions of separate species have, at one time or another, evolved. the process whereby one species splits into two is called speciation. Subsequent divergence leads to ever wider separation of taxonomic units - genera, families, orders, classes, etc. Even creatures as different as, say, snails and monkeys, are derived from ancestors who originally diverged from a single species in a speciation event.

Since the 1940s it has been widely accepted that the first step in the origin of species is normally geographical separation. A species is accidentally divided into two geographically separated populations. Often there may be sub-populations isolated on islands, where the word is generalised to include islands of water in land (lakes), islands of vegetation in deserts (oases) etc. Even trees in a meadow may be effective islands to some of their small inhabitants. Geographical isolation means no gene flow, no sexual contamination of each gene pool by the other. Under these conditions the average gene frequencies in the two gene pools can change, either because of different selection pressures or because of random statistical changes in the two areas, After sufficient genetic divergence while in geographical isolation, the two sub-populations are no longer capable of interbreeding even if later circumstances chance to re-unite them. When they can no longer interbreed, speciation is said to have occurred and a new species (or two) is said to have come into being. It is controversial whether geographical separation is always necessarily implicated in speciation.

Darwin made a distinction between natural selection, which favours organs and devices for survival, and sexual selection which favours competitive success in gaining mates, either by direct combat with members of the same sex, or by being attractive to the opposite sex (these are sometimes called intrasexual selection and intersexual selection, respectively, but the usage is misleading). Darwin was impressed by the fact that qualities of sexual attractiveness were often the reverse of qualities leading to individual survival. the gaudy and cumbersome tails of birds of paradise are a notorious example. they must hamper their possessors in flight, and certainly they are conspicuous to predators, but Darwin realised that this could be 'worth it' if the tails also attractive females. A male who manages to persuade a female to mate with him rather than with a rival is likely to contribute his genes to future gene pools. Genes for sexually attractive tails willy-nilly have an advantage that compensates for their admitted disadvantages.

the philosopher Daniel Dennett has written: "Let me lay my cards on the table. If I were to give an award for the single best idea anyone has ever had, I'd give it to Darwin, ahead of Newton and Einstein and everyone else." Comparative judgments like that are hard to make. But on one criterion Darwin's contribution surely heads the field. the sheer power of the idea, measured as the amount of explanatory work that it does, divided by the extreme simplicity of the idea itself, leaves one astonished that humanity had to wait till the mid nineteenth century before one of us thought of it.

My Short Interview with
Richard Dawkins
by Lanny Swerdlow

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Home to Positive Atheism

Lanny Swerdlow: Hi! With me today is Dr. Richard Dawkins, author of The Selfish Gene, the revolutionary book (as far as I'm concerned) The Blind Watchmaker, and his newest book, Climbing -- er...

Richard Dawkins: ...Mount Improbable.

Lanny Swerdlow: Climbing Mount Improbable. I've got a couple of questions that, ever since I've read the book, I've always wanted to ask you. They're kind of grand in their scope of things, they're not particularly specific. In your book The Blind Watchmaker, I believe that you made the argument that the principles of evolution apply everywhere in the universe. In other words, the laws of thermodynamics apply on a planet a hundred-billion light years away from the earth as well as they apply on the earth. So the principles of evolution apply on that planet as much as they would on earth.

Richard Dawkins: It's a less-strong claim than for the laws of thermodynamics. I think for the laws of thermodynamics we more or less know that they apply everywhere in the universe. The laws of Darwinian evolution: First off, we don't know if there's life anywhere else in the universe; there may not be. It is actually seriously possible that we may be alone in the universe. Assuming that there is other life in the universe (and I think most people think that there is), then my conjecture is that how ever alien and different it may be in detail (the creatures may be so different from us that we may hardly recognize them as living at all), if they have the property of organized complexity and apparent design -- adaptive complexity -- then I believe that something equivalent to Darwinian natural selection -- gradual evolution by Darwinian natural selection; that is, the non-random survival of randomly varying hereditary elements -- will turn out to be applied. All life in the universe, my guess is, will have evolved by some equivalent to Darwinism.

Lanny Swerdlow: Also from reading your book The Blind Watchmaker, I kind of pick up the idea that the mechanism of evolution not only apply to origin of species, or DNA survival, but in a way, apply to everything in the universe, from quarks to galaxies.

Richard Dawkins: I would prefer not to say that. I certainly haven't said that in any of my books, and I would be reluctant to say that. I think that something very special happens in the universe, when a self-replicating entity, which DNA is -- DNA is probably not the only one, but DNA is the self-replicating entity that we know. When that comes into existence, then there is a whole new game that starts. Before that, you had just physics; you have molecules bumping around, forming new molecules according to the ordinary laws of chemistry. Once, by those ordinary laws of chemistry, a molecule springs into existence which is self-replicating, then immediately you have the possibility for Darwinism, for natural selection to occur. Then you have this extraordinary process, which we only know of on this planet, but may exist elsewhere, whereby things start to get more complicated and start to appear as though they've been really designed for a purpose. If you look carefully for what that purpose is, it turns out to be to replicate, to pass on, to propagate that very same DNA, or whatever it might be.

Lanny Swerdlow: People will sometimes look at the physical universe and say it looks like it was designed.... Isn't the fact that a solar system survives based on [the fact that] it has properties which will ensure its survival, versus another solar system that is unstable?

Richard Dawkins: So you're kind of trying to make a Darwinian view of solar systems.... In a way, but let me make a distinction, then, between what we call one-off or single-generation selection, and cumulative, multi-generation selection. A solar system survives because -- let's say, a planet orbiting a star will orbit the star at a particular distance, which is the right distance for that planet and that star. That's the crucial distance. If it was orbiting faster, it would whiz off into deep space; if it were orbiting slower, it would spiral into the star. So, there is a kind of selection of planets to be orbiting at the right speed and at the right distance from their stars.

But that's not cumulative selection, that's one-off, single-generation selection. It's like one generation of biological selection. It's like finches who have the wrong size of beak for a hard winter. The ones with the wrong size of beak die, so in the next winter, the next generation have all got the right size of beak. That's one generation.

What's really crucial about biological evolution is that that doesn't stop at one generation, it goes on to the next and the next and the next, and it takes hundreds, it takes thousands of generations to build up, cumulatively, the really impressive adaptive complexity that we get in living things, like eyes and elbow joints. So, that's the reason why solar systems don't look very impressively designed, whereas living bodies look very, very impressively designed indeed. They've been through many generations of cumulative selection.

Lanny Swerdlow: I was listening to your previous interview and a question popped into my mind that I wanted to ask; it's kind of a hot-button question. They asked you a question about children being gullible and you explained that this is an adaptive mechanism, that they have a lot to learn when they're young, so they'll take in a lot of information. Some of the information is good, some of the information is bad, and the problem is that once they've taken in this information they're pretty well set for the rest of their lives. Is this one of the reasons explaining why religion and belief in supernatural forces is so ingrained in people because it's indoctrinated into them when they're very young and very gullible? and even when they get older and can start reasoning better, it's been so ingrained into them that they can't get out of it?

Richard Dawkins: Yes, I do think that. What would be consistent with that view is the fact that (really, rather remarkably) of the people who are religious, the religion that they have is almost always the same as that of their parents. Very occasionally, it isn't. This is an almost unique feature about people's beliefs. We talk about a child as being a 4-year-old Muslim or a 4-year-old Catholic. You would never dream about talking about a 4-year-old economic monitorist or a 4-year-old neo-isolationist, and yet, you can see the parallel.

Lanny Swerdlow: Yes!

Richard Dawkins: Children really ought not be spoken of as a Catholic child or a Muslim child. They ought to be allowed to grow until they're old enough to decide for themselves what their beliefs about the cosmos are. But ... the fact [is] that we do treat [children] that way, and ... parents seem to be regarded as having a unique right to impose their religious beliefs on their child; whereas, nobody thinks they're going to impose their beliefs about -- I don't know -- why the dinosaurs went extinct, or something of that sort. But religion is different. And I do think that you can explain an awful lot about religion if you assume that children start out gullible. Anything that is told to them with sufficient force -- particularly if it's reinforced by some kind of threat, like, "If you don't believe this, you'll go to hell when you die" -- then it is going to get passed on to the next generation. Above all, "You must believe this, and when you grow up, you must teach your children the same thing." That, of course, is precisely how religions get promoted, how they do get passed on from generation to generation.

Lanny Swerdlow: Almost sounds Darwinian! Last question, last night ... I saw ... the program, and I read about you, and then they had a little squib, in the program, of somebody opposing you. I was kind of taken aback by that.... Obviously, what you're talking about is very controversial, because some people who are religious feel it's attacking their very basic religious beliefs. I wonder if you might have a comment on -- here's a science group that, for some reason, feels so pressured by religions (or something), that they'll do an extraordinary thing by putting a religious argument in a Program; something they've never done before. How do you react to that?

Richard Dawkins: I think that you're overreacting to this particular thing. I think that when somebody's trying to sell tickets, it's quite good to put in a -- er, some negative, um -- I don't blame them for that at all. The particular extract that was put in was not by any known person. It was just a letter to the editor of a journal in which I'd had an article published. The person who wrote it is not somebody I've ever heard of; it was not a refereed article. It was just that if you say anything in the press that remotely treads on people's religious toes, all hell breaks loose. You always get a great mailbag full of stuff. Now, I just throw it straight in the bin! Newspapers, obviously, have a duty to publish some random selection of the papers that they get in, and I think that's what happened in this case.

Lanny Swerdlow: Finally, ... do you see the concepts of evolution as sort of an atheistic explanation of the origins of life? And, is that why the religions have so much problem with it, because it undermines their basic foundations?

Richard Dawkins: Well, evolution is different about this, because there are a large number of evolutionists who are also religious. You cannot be both sane and well educated and disbelieve in evolution. The evidence is so strong that any sane, educated person has got to believe in evolution. Now there are plenty of sane, educated, religious people: there are professors of theology, and there are bishops ... and so obviously they all believe in evolution or they wouldn't have gotten where they have because they would be too stupid or too ignorant. So, it is a fact that there are evolutionists who are religious and there are religious people who are evolutionists.

My own personal feeling is that it is rather difficult. I find that the reason that I am no longer religious is that the argument from design has been undermined by evolution. So if the basis for your religion is the argument from design, if the reason why you are religious is that you look at the world and you say, "Isn't it beautifully designed! Isn't it elegant! Isn't it complicated!" then Darwinism really does pull the rug out from under that argument. If your reason for being religious has nothing to do with that, if your reason for being religious is some still, small voice inside you which utterly convinces you, then the argument from design, I suppose, has no bearing on that. But what, I think, Darwinism has done is utterly to destroy the argument from design which, I believe, is probably, historically, the dominant reason for believing in a supernatural being.

Lanny Swerdlow: Thank you very much! I sure appreciate your time.

Richard Dawkins: Thank you.

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RICHARD DAWKINS

Selfish Genes And Selfish Memes

Selfish Genes

In the beginning was simplicity. It is difficult enough explaining how even a simple universe began. I take it as agreed that it would be even harder to explain the sudden springing up, fully armed, of complex order-life, or a being capable of creating life. Darwin's theory of evolution by natural selection is satisfying because it shows us a way in which simplicity could change into complexity, how unordered atoms could group themselves into ever more complex patterns until they ended up manufacturing people. Darwin provides a solution, the only feasible one so far suggested, to the deep problem of our existence. I will try to explain the great theory in a more general way than is customary, beginning with the time before evolution itself began.

Darwin's `survival of the fittest' is really a special case of a more general law of *survival of the stable*. The universe is populated by stable things. A stable thing is a collection of atoms which is permanent enough or common enough to deserve a name. It may be a unique collection of atoms, such as the Matterhorn, which lasts long enough to be worth naming. `Or it may be a *class* of entities, such as rain drops, which come into existence at a sufficiently high rate to deserve a collective name, even if any one of them is short-lived. The things which we see around us, and which we think of as needing explanation-rocks, galaxies, ocean waves -are all, to a greater or lesser extent, stable patterns of atoms. Soap bubbles tend to be spherical because this is a stable configuration for thin films filled with gas. In a spacecraft, water is also stable in spherical globules, but on earth, where there is gravity, the stable surface for standing water is flat and horizontal. Salt crystals tend to be cubes because this is a stable way of packing sodium and chloride ions together. In the sun the simplest atoms of all, hydrogen atoms, are fusing to form helium atoms, because in the conditions which prevail there the helium configuration is more stable. Other even more complex atoms are being formed in stars all over the universe, and were formed in the "big bang" which, according to the prevailing theory, initiated the universe. This is originally where the elements on our world came from.

Sometimes when atoms meet they link up together in chemical reaction to form molecules, which may be more or less stable. Such molecules can be very large. A crystal such as a diamond can be regarded as a single molecule, a proverbially stable one in this case, but also a very simple one since its internal atomic structure is endlessly repeated. In modern living organisms there are other large molecules which are highly complex, and their complexity shows itself on several levels. The hemoglobin of our blood is a typical protein molecule. It is built up from chains of smaller molecules, amino acids, each containing a few dozen atoms arranged in a precise pattern. In the hemoglobin molecule there are 574 amino acid molecules. These are arranged in four chains, which twist around each other to form a globular three-dimensional structure of bewildering complexity. A model of a hemoglobin molecule looks rather like a dense thornbush. But unlike a real thornbush it is not a haphazard approximate pattern but a definite invariant structure, identically repeated, with not a twig nor a twist out of place, over six thousand million million million times in an average human body. The precise thornbush shape of a protein molecule such as hemoglobin is stable in the sense that two chains consisting of the same sequences of amino acids will tend, like two springs, to come to rest in exactly the same three-dimensional coiled pattern. Hemoglobin thornbushes are springing into their "preferred" shape in your body at a rate of about four hundred million million per second, and others are being destroyed at the same rate.

Hemoglobin is a modern molecule, used to illustrate the principle that atoms tend to fall into stable patterns. The point that is relevant here is that, before the coming of life on earth, some rudimentary evolution fo molecules could have occurred by ordinary processes of physics and chemistry. There is no need to think of design or purpose or directedness. If a group of atoms in the presence of energy falls into a stable pattern it will tend to stay that way. The earliest form of natural selection was simply a selection of stable forms and a rejection of unstable ones. There is no mystery about this. It had to happen by definition.

From this, of course, it does not follow that you can explain the existence of entities as complex as man by exactly the same principles on their own. It is no good taking the right number of atoms and shaking them together with some external energy till they happen to fall into the right pattern, and out drops Adam! You may make a molecule consisting of a few dozen atoms like that, but a man consists of over a thousand million million million million atoms. To try to make a man, you would have to work at your biochemical cocktail-shaker for a period so long that the entire age of the universe would seem like an eye-blink, and even then you would not succeed. This is where Darwin's theory, in its most general form, comes to the rescue. Darwin's theory takes over from where the story of the slow building up of molecules leaves off.

The account of the origin of life which I shall give is necessarily speculative; by definition, nobody was around to see what happened. There are a number of rival theories, but they all have certain features in common. The simplified account I shall give is probably not too far from the truth.

We do not know what chemical raw materials were abundant on earth before the coming of life, but among the plausible possibilities are water, carbon dioxide, methane, and ammonia: all simple compounds known to be present on at least some of the other planets in our solar system. Chemists have tried to imitate the chemical conditions of the young earth. They have put these simple substances in a flask and supplied a source of energy such as ultraviolet light or electric sparksartificial simulation of primordial lightning. After a few weeks of this, something interesting is usually found inside the flask: a weak brown soup containing a large number of molecules more complex than the ones originally put in. In particular, amino acids have been found-the building blocks of proteins, one of the two great classes of biological molecules. Before these experiments were done, naturally occurring amino acids would have been thought of as diagnostic of the presence of life. If they had been detected on, say, Mars, life on that planet would have seemed a near certainty. Now, however, their existence need imply only the presence of a few simple gases in the atmosphere and some volcanoes, sunlight, or thundery weather. More recently, laboratory simulations of the chemical conditions of earth before the coming of life have yielded organic substances called purines and pyrimidines. These are building blocks of the genetic molecule, DNA itself.

Processes analogous to these must have given rise to the "primeval soup" which biologists and chemists believe constituted the seas some three to four thousand million years ago. The organic substances became locally concentrated, perhaps in drying scum round the shores, or in tiny suspended droplets. Under the further influence of energy such as ultraviolet light from the sun, they combined into larger molecules. Nowadays large organic molecules would not last long enough to be noticed: they would be quickly absorbed and broken down by bacteria or other living creatures. But bacteria and the rest of us are late-comers, and in those days large organic molecules could drift unmolested through the thickening broth.

At some point a particularly remarkable molecule was formed by accident. We will call it the Replicator. It may not necessarily have been the biggest or the most complex molecule around, but it had the extraordinary property of being able to create copies of itself. This may seem a very unlikely sort of accident to happen. So it was. It was exceedingly improbable. In the lifetime of a man, things which are that improbable can be treated for practical purposes as impossible. That is why you will never win a big prize on the football pools. But in our human estimates of what is probable and what is not, we are not used to dealing in hundreds of millions of years. If you filled in pools coupons every week for a hundred million years you would very likely win several jackpots.

Actually a molecule which makes copies of itself is not as difficult to imagine as it seems at first, and it only had to arise once. Think of the replicator as a mold or template. Imagine it as a large molecule consisting of a complex chain of various sorts of building block molecules. The small building blocks were abundantly available in the soup surrounding the replicator. Now suppose that each building block has an affinity for its own kind. Then whenever a building block from out in the soup lands up next to a part of the replicator for which it has an affinity, it will tend to stick there. The building blocks which attach themselves in this way will automatically be arranged in a sequence which mimics that of the replicator itself. It is easy then to think of them joining up to form a stable chain just as in the formation of the original replicator. This process could continue as a progressive stacking up, layer upon layer. This is how crystals are formed. On the other hand, the two chains might split apart, in which case we have two replicators, each of which can go on to make further copies.

A more complex possibility is that each building block has affinity not for its own kind, but reciprocally for one particular other kind. Then the replicator would act as a template not for an identical copy, but for a kind of "negative," which would in its turn remake an exact copy of the original positive. For our purposes it does not matter whether the original replication process was positive-negative or positive-positive, though it is worth remarking that the modern equivalents of the first replicator, the DNA molecules, use positive-negative replication. What does matter is that suddenly a new kind of "stability" came into the world. Previously it is probable that no particular kind of complex molecule was very abundant in the soup, because each was dependent on building blocks happening to fall by luck into a particular stable configuration. As soon as the replicator was born it must have spread its copies rapidly throughout the seas, until the smaller building block molecules became a scarce resource, and other larger molecules were formed more and more rarely.

So we seem to arrive at a large population of identical replicas. But now we must mention an important property of any copying process: it is not perfect. Mistakes will happen. I hope there are no misprints in this book, but if you look carefully you may find one or two. They will probably not seriously distort the meaning of the sentences, because they will be "first-generation" errors. But imagine the days before printing, when books such as the Gospels were copied by hand. All scribes, however careful, are bound to make a few errors, and some are not above a little willful "improvement." If they all copied from a single master original, meaning would not be greatly perverted. But let copies be made from other copies, which in their turn were made from other copies, and errors will start to become cumulative and serious. We tend to regard erratic copying as a bad thing, and in the case of human documents it is hard to think of examples where errors can be described as improvements. I suppose the scholars of the Septuagint could at least be said to have started something big when they mistranslated the Hebrew word for "young woman" into the Greek word for "virgin," coming up with the prophecy: "Behold a virgin shall conceive and bear a son...." Anyway, as we shall see, erratic copying in biological replicators can in a real sense give rise to improvement, and it was essential for the progressive evolution of life that some errors were made. We do not know how accurately the original replicator molecules made their copies. Their modern descendants, the DNA molecules, are astonishingly faithful compared with the most high-fidelity human copying process, but even they occasionally make mistakes, and it is ultimately these mistakes which make evolution possible. Probably the original replicators were far more erratic, but in any case we may be sure that mistakes were made, and these mistakes were cumulative.

As mis-copyings were made and propagated, the primeval soup became filled by a population not of identical replicas, but of several varieties of replicating molecules, all "descended" from the same ancestor. would some varieties have been more numerous than others? Almost certainly yes. Sonic varieties would have been inherently more stable than others. Certain molecules, once formed, would be less likely than others to break tip again. These types would become relatively numerous in the soup, not only as a direct logical consequence of their "longevity," but also because they would have a long time available for making copies of themselves. Replicators of high longevity would therefore tend to become more numerous and, other things being equal, there would have been an "evolutionary trend" toward greater longevity in the population of molecules.

But other things were probably not equal, and another property of a replicator variety which must have had even more importance in spreading it through the population was speed of replication, or "fecundity." If replicator molecules of type A make copies of themselves on average once a week while those of type *B* make copies of themselves once an hour, it is not difficult to see that pretty soon type A molecules are going to be far outnumbered, even if they "live" much longer than *B* molecules. There would therefore probably have been an "evolutionary trend" towards higher "fecundity" of molecules in the soup. A third characteristic of replicator molecules which would have been positively selected is accuracy of replication. If molecules of type X and type Y last the same length of time and replicate at the same rate, but X makes a mistake on average every tenth replication while I' makes a mistake only every hundredth replication, I' will obviously become more numerous. The X contingent in the population loses not only the errant "children" themselves, but also all their descendants, actual or potential.

If you already know something about evolution, you may find something slightly paradoxical about the last point. Can we reconcile the idea that copying errors are an essential prerequisite for evolution to occur, with the statement that natural selection favors high copying-fidelity? The answer is that although evolution may seem, in some vague sense, a "good thing," especially since we are the product of it, nothing actually "wants" to evolve. Evolution is something that happens, willy-nilly, in spite of all the efforts of the replicators (and nowadays of the genes) to prevent it happening. Jacques Monod made this point yen- well in his Herbert Spencer lecture, after wryly remarking: "Another curious aspect of the theory of evolution is that everybody thinks he understands it!"

To return to the primeval soup, it must have become populated by stable varieties of molecule: stable in that either the individual molecules lasted a long time, or they replicated rapidly, or they replicated accurately. Evolutionary trends toward these three kinds of stability took place in the following sense: If you had sampled the soup at two different times, the later sample would have contained a higher proportion of varieties with high longevity/fecundity/copying-fidelity. This is essentially what a biologist means by evolution when he is speaking of living creatures, and the mechanism is the same-natural selection.

Should we then call the original replicator molecules "living"? Who cares? I might say to you "Darwin was the greatest man who has ever lived," and you might say, "No, Newton was," but I hope we would not prolong the argument. The point is that no conclusion of substance would be affected whichever way our argument was resolved. The facts of the lives and achievements of Newton and Darwin remain totally unchanged whether we label them "great" or not. Similarly, the story of the replicator molecules probably happened something like the way I am telling it, regardless of whether we choose to call them "living." Human suffering has been caused because too many of us cannot grasp that words are only tools for our use, and that the mere presence in the dictionary of a word like "living" does not mean it necessarily has to refer to something definite in the real world. Whether we call the early replicators living or not, they were the ancestors of life; they were our founding fathers.

The next important link in the argument, one which Darwin himself laid stress on (although he was talking about animals and plants, not molecules) *is competition.* The primeval soup was not capable of supporting an infinite number of replicator molecules. For one thing, the earth's size is finite, but other limiting factors must also have been important. In our picture of the replicator acting as a template or mold, we supposed it to be bathed in a soup rich in the small building block molecules necessary to make copies. But when the replicators became numerous, building blocks must have been used up at such a rate that they became a scarce and precious resource. Different varieties or strains of replicator must have competed for them. We have considered the factors which would have increased the numbers of favored kinds of replicator. We can now see that less-favored varieties must actually have become *less* numerous because of competition, and ultimately many of their lines must have gone extinct. There was a struggle for existence among replicator varieties. They did not know they were struggling, or worry about it; the struggle was conducted without any hard feelings, indeed without feelings of any kind. But they were struggling, in the sense that any miscopying which resulted in a new higher level of stability, or a new way of reducing the stability of rivals, was automatically preserved and multi plied. The process of improvement was cumulative. Ways of increasing stability and of decreasing rivals' stability became more elaborate and more efficient. Some of them may even have "discovered" how to break up molecules of rival varieties chemically, and to use the building blocks so released for making their own copies. These proto-carnivores simultaneously obtained food and removed competing rivals. Other replicators perhaps discovered how to protect themselves, either chemically or by building a physical wall of protein around themselves. This may have been how the first living cells appeared. Replicators began not merely to exist, but to construct for themselves containers, vehicles for their continued existence. The replicators which survived were the ones which built *survival machines* for themselves to live in. The first survival machines probably consisted of nothing more than a protective coat. But making a living got steadily harder as new rivals arose with better and more effective survival machines. Survival machines got bigger and more elaborate, and the process was cumulative and progressive.

Was there to be any end to the gradual improvement in the techniques and artifices used by the replicators to ensure their own continuance in the world? There would be plenty of time for improvement. What weird engines of self-preservation would the millennia bring forth? Four thousand million years on, what was to be the fate of the ancient replicators? They did not die out, for they are past masters of the survival arts. But do not look for them floating loose in the sea; they gave up that cavalier freedom long ago. Now they swarm in huge colonies, safe inside gigantic lumbering robots, sealed off from the outside world, communicating with it by tortuous indirect routes, manipulating it by remote control. They are in you and in me; they created us, body and mind; and their preservation is the ultimate rationale for our existence. They have come a long way, those replicators. Now they go by the name of genes, and we are their survival machines.

* * *

Once upon a time, natural selection consisted of the differential survival of replicators floating free in the primeval soup. Now natural selection favors replicators which are good at building survival machines, genes which are skilled in the art of controlling embryonic development. In this, the replicators are no more conscious or purposeful than they ever were. The same old processes of automatic selection between rival molecules by reason of their longevity, fecundity, and copying-fidelity, still go on as blindly and as inevitably as they did in the far-off days. Genes have no foresight. They do not plan ahead. Genes just *are*, some genes more so than others, and that is all there is to it. But the qualities which determine a gene's longevity and fecundity are not so simple as they were. Not by a long way.

In recent years-the last six hundred million or so-the replicators have achieved notable triumphs of survival-machine technology such as the muscle, the heart, and the eye (evolved several times independently). Before that, they radically altered fundamental features of their way of life as replicators, which must be understood if we are to proceed with the argument.

The first thing to grasp about a modern replicator is that it is highly gregarious. A survival machine is a vehicle containing not just one gene but many thousands. The manufacture of a body is a cooperative venture of such intricacy that it is almost impossible to disentangle the contribution of one gene from that of another. A given gene will have many different effects on quite different parts of the body. A given part of the body will be influenced by many genes, and the effect of any one gene depends on interaction with many others. Some genes act as master genes controlling the operation of a cluster of other genes. In terms of the analogy, any given page of the plans makes reference to many different parts of the building; and each page makes sense only in terms of cross-references to numerous other pages.

This intricate interdependence of genes may make you wonder why we use the word "gene" at all. Why not use a collective noun like "gene complex"? The answer is that for many purposes that is indeed quite a good idea. But if we look at things in another way, it does make sense too to think of the gene complex as being divided up into discrete replicators or genes. This arises because of the phenomenon of sex. Sexual reproduction has the effect of mixing and shuffling genes. This means that any one individual body is just a temporary vehicle for a short-lived combination of genes. The *combination* of genes that is any one individual may be short-lived, but the genes themselves are potentially very long-lived. Their paths constantly cross and recross down the generations. One gene may be regarded as a unit which survives through a large number of successive individual bodies.

* * *

Natural selection in its most general form means the differential survival of entities. Some entities live and others die but, in order for this selective death to have any impact on the world, an additional condition must be met. Each entity must exist in the form of lots of copies, and at least some of the entities must be *potentially* capable of surviving-in the form of popies-for a significant period of evolutionary time. Small genetic units have these properties; individuals, groups, and species do not. It was the great achievement of Gregor Mendel to show that hereditary units can be treated in practice as indivisible and independent particles. Nowadays we know that this is a little too simple. Even a cistron is occasionally divisible and any two genes on the same chromosome are not wholly independent. What I have done is to define a gene as a unit which, to a high degree, *approaches* the ideal of indivisible particulateness. A gene is not indivisible, but it is seldom divided. It is either definitely present or definitely absent in the body of any given individual. A gene travels intact from grandparent to grandchild, passing straight through the intermediate generation without being merged with other genes. If genes continually blended with each other, natural selection as we now understand it would be impossible. Incidentally, this was proved in Darwin's lifetime, and it caused Darwin great worry since in those days it was assumed that heredity was a blending process. Mendel's discovery had already been published, and it could have rescued Darwin, but alas he never knew about it: nobody seems to have read it until years after Darwin and Mendel had both died. Mendel perhaps did not realize the significance of his findings, otherwise he might have written to Darwin.

Another aspect of the particulateness of the gene is that it does not grow senile; it is no more likely to die when it is a million years old than when it is only a hundred. It leaps from body to body down the generations, manipulating body after body in its own way and for its own ends, abandoning a succession of mortal bodies before they sink in senility and death.

The genes are the immortals, or rather, they are defined as genetic entities which come close to deserving the title. We, the individual survival machines in the world, can expect to live a few more decades. But the genes in the world have an expectation of life which must be measured not in decades but in thousands and millions of years.

* * *

Survival machines began as passive receptacles for the genes, providing little more than walls to protect them from the chemical warfare of their rivals and the ravages of accidental molecular bombardment. In the early days they "fed" on organic molecules freely available in the soup. This easy life came to an end when the organic food in the soup, which had been slowly built up under the energetic influence of centuries of sunlight, was all used up. A major branch of survival machines, now called plants, started to use sunlight directly thx themselves to build up complex molecules from simple ones, reenacting at much higher speed the synthetic processes of the original soup. Another branch, now known as animals, "discovered" how to exploit the chemical labors of the plants, either by eating them, or by eating other animals. Both main branches of survival machines evolved more and more ingenious tricks to increase their efficiency in their various ways of life, and new ways of life were continually being opened up. Subbranches and sub-subbranches evolved, each one excelling in a particular specialized way of making a living: in the sea, on the ground, in the air, underground, up trees, inside other living bodies. This subbranching has given rise to the immense diversity of animals and plants which so impresses us today.

Both animals and plants evolved into many-celled bodies, complete copies of all the genes being distributed to every cell. We do not know when, why, or how many times independently, this happened. Some people use the metaphor of a colony, describing a body as a colony of cells. I prefer to think of the body as a colony of *genes,* and of the cell as a convenient working unit for the chemical industries of the genes.

Colonies of genes they may be but, in their behavior, bodies have undeniably acquired an individuality of their own. An animal moves as a coordinated whole, as a unit. Subjectively I feel like a unit, not a colony. This is to be expected. Selection has favored genes which cooperate with others. In the fierce competition for scarce resources, in the relentless struggle to eat other survival machines, and to avoid being eaten, there must have been a premium on central coordination rather than anarchy within the communal body. Nowadays the intricate mutual coevolution of genes has proceeded to such an extent that the communal nature of an individual survival machine is virtually unrecognizable. Indeed many biologists do not recognize it, and will disagree with me.

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One of the most striking properties of survival-machine behavior is its apparent purposiveness. By this I do not just mean that it seems to be well calculated to help the animal's genes to survive, although of course it is. I am talking about a closer analogy to human purposeful behavior. When we watch an animal "searching" for food, or for a mate, or for a lost child, we can hardly help imputing to it some of the subjective feelings we ourselves experience when we search. These may include "desire" for some object, a "mental picture" of the desired object, an "aim" or "end in view." Each one of us knows, from the evidence of his own introspection, that, at least in one modern survival machine, this purposiveness has evolved the property we call "consciousness." I am not philosopher enough to discuss what this means, but fortunately it does not matter for our present purposes because it is easy to talk about machines which behave as *if* motivated by a purpose, and to leave open the question whether they actually are conscious. These machines are basically very simple, and the principles of unconscious purposive behavior are among the commonplaces of engineering science. The classic example is the Watt steam governor.

The fundamental principle involved is called negative feedback, of which there are various different forms. In general what happens is this. The "purpose machine," the machine or thing that behaves as if it had a conscious purpose, is equipped with some kind of measuring device which measures the discrepancy between the current state of things and the "desired" state. It is built in such a way that the larger this discrepancy is, the harder the machine works. In this way the machine will automatically tend to reduce the discrepancy-this is why it is called *negative* feedback-and it may actually come to rest if the "desired" state is reached. The Watt governor consists of a pair of balls which are whirled round by a steam engine. Each ball is on the end of a hinged arm. The faster the balls fly round, the more does centrifugal force push the arms toward a horizontal position, this tendency being resisted by gravity. The arms are connected to the steam valve feeding the engine, in such a way that the steam tends to be shut off when the arms approach the horizontal position. So, if the engine goes too fast, some of its steam will be shut off, and it will tend to slow down. If it slows down too much, more steam will automatically be fed to it by the valve, and it will speed up again. Such purpose machines often oscillate due to overshooting and time-lags, and it is part of the engineer's art to build in supplementary devices to reduce the oscillations.

The "desired" state of the Watt governor is a particular speed of rotation. Obviously it does not consciously desire it. The "goal" of a machine is simply defined as that state to which it tends to return. Modern purpose machines use extensions of basic principles like negative feedback to achieve much more complex "lifelike" behavior. Guided missiles, for example, appear to search actively for their target, and when they have it in range they seem to pursue it, taking account of its evasive twists and turns, and sometimes even "predicting" or "anticipating" them. The details of how this is done are not worth going into. They involve negative feedback of various kinds, "feed-forward," and other principles well understood by engineers and now known to be extensively involved in the working of living bodies. Nothing remotely approaching consciousness needs to be postulated, even though a layman, watching its apparently deliberate and purposeful behavior, finds it hard to believe that the missile is not under the direct control of a human pilot.

It is a common misconception that because a machine such as a guided missile was originally designed and built by conscious man, then it must be truly under the immediate control of conscious man. Another variant of this fallacy is "computers do not really play chess, because they can only do what a human operator tells them." It is important that we understand why this is fallacious, because it affects our understanding of the sense in which genes can be said to "control" behavior. Computer chess is quite a good example for making the point, so I will discuss it briefly.

Computers do not yet play chess as well as human grand masters, but they have reached the standard of a good amateur. More strictly, one should say programs have reached the standard of a good amateur, for a chess-playing program is not fussy which physical computer it uses to act out its skills. Now, what is the role of the human programmer? First, he is definitely not manipulating the computer from moment to moment, like a puppeteer pulling strings. That would be just cheating. He writes the program, puts it in the computer, and then the computer is on its own: there is no further human intervention, except for the opponent typing in his moves. Does the programmer perhaps anticipate all possible chess positions and provide the computer with a long list of good moves, one for each possible contingency? Most certainly not, because the number of possible positions in chess is so great that the world would come to an end before the list had been completed. For the same reason, the computer cannot possibly be programmed to try out "in its head" all possible moves, and all possible follow-ups, until it finds a winning strategy. There are more possible games of chess than there are atoms in the galaxy. So much for the trivial nonsolutions to the problem of programming a computer to play chess. It is in fact an exceedingly difficult problem, and it is hardly surprising that the best programs have still not achieved grand master status.

The programmer's actual role is rather more like that of a father teaching his son to play chess. He tells the computer the basic moves of the game, not separately for every possible starting position, but in terms of more economically expressed rules. He does not literally say in plain English "bishops move in a diagonal," but he does say something mathematically equivalent, such as, though more briefly: "New coordinates of bishop are obtained from old coordinates, by adding the same constant, though not necessarily with the same sign, to both old x coordinate and old y coordinate." Then he might program in some "advice," written in the same sort of mathematical or logical language, but amounting in human terms to hints such as "don't leave your king unguarded," or useful tricks such as "forking" with the knight. The details are intriguing, but they would take us too far afield. The important point is this: When it is actually playing, the computer is on its own and can expect no help from its master. All the programmer can do is to set the computer up beforehand in the best way possible, with a proper balance between lists of specific knowledge and hints about strategies and techniques.

The genes too control the behavior of their survival machines, not directly with their fingers on puppet strings, but indirectly like the computer programmer. All they can do is to set it up beforehand; then the survival machine is on its own, and the genes can only sit passively inside. Why are they so passive? Why don't they grab the reins and take charge from moment to moment? The answer is that they cannot because of timelag problems. This is best shown by another analogy, taken from science fiction. Af for Andromeda by Fred Hoyle and John Elliot is an exciting story, and, like all good science fiction, it has some interesting scientific points lying behind it. Strangely, the book seems to lack explicit mention of the most important of these underlying points. It is left to the reader's imagination. I hope the authors will not mind if I spell it out here.

There is a civilization two hundred light years away, in the constellation of Andromeda. * They want to spread their culture to distant worlds. How best to do it? Direct travel is out of the question. The speed of light imposes a theoretical upper limit to the rate at which you can get from one place to another in the universe, and mechanical considerations impose a much lower limit in practice. Besides, there may not be all that mare worlds worth going to, and how do you know which direction to go in? Radio is a better way of communicating with the rest of the universe, since, if you have enough power to broadcast your signals in all directions rather than beam them in one direction, you can reach a very large number of worlds (the number increasing as the square of the distance the signal travels). Radio waves travel at the speed of light, which means the signal takes two hundred years to reach Earth from An-' dromeda. The trouble with this sort of distance is that you can never hold a conversation. Even if you discount the fact that each successive message from Earth would be transmitted by people separated from each other by twelve generations or so, it would be just plain wasteful to attempt to converse over such distances.

This problem will soon arise in earnest for us: it takes about four minutes for radio waves to travel between Earth and Mars. There can be no doubt that spacemen will have to get out of the habit of conversing

*Not to he confused with the Andromeda galaxy, which is two million light years away.
-Eds.

in short alternating sentences, and will have to use long soliloquies or monologues, more like letters than conversations. As another example, Roger Payne has pointed out that the acoustics of the sea have certain peculiar properties, which mean that the exceedingly loud "song" of the humpback whale could theoretically be heard all the way round the world, provided the whales swim at a certain depth. It is not known whether they actually do communicate with each other over very great distances, but if they do they must be in much the same predicament as an astronaut on Mars. The speed of sound in water is such that it would take nearly two hours for the song to travel across the Atlantic Ocean and for a reply to return. I suggest this as an explanation for the fact that the whales deliver a continuous soliloquy, without repeating themselves, for a full eight minutes. They then go back to the beginning of the song and repeat it all over again, many times over, each complete cycle lasting about eight minutes.

The Andromedans of the story did the same thing. Since there was no point in waiting for a reply, they assembled everything they wanted to say into one huge unbroken message, and then they broadcast it out into space, over and over again, with a cycle time of several months. Their message was very different from that of the whales, however. It consisted of coded instructions for the building and programming of a giant computer. Of course the instructions were in no human language, but almost any code can be broken by a skilled cryptographer, especially if the designers of the code intended it to be easily broken. Picked up by the Jodrell Bank radio telescope, the message was eventually decoded, the computer built, and the program run. The results were nearly disastrous for mankind, for the intentions of the Andromedans were not universally altruistic, and the computer was well on the way to dictatorship over the world before the hero eventually finished it off with an axe.

From our point of view, the interesting question is in what sense the Andromedans could be said to be manipulating events on Earth. They had no direct control over what the computer did from moment to moment; indeed they had no possible way of even knowing the computer had been built, since the information would have taken two hundred years to get back to them. The decisions and actions of the computer were entirely its own. It could not even refer back to its masters for general policy instructions. All its instructions had to be built-in in advance, because of the inviolable two-hundred-year barrier. In principle, it must have been programmed very much like a chess-playing computer, but with greater flexibility and capacity for absorbing local information. This was because the program had to be designed to work not just on earth, but on any world possessing an advanced technology, any of a set of worlds whose detailed conditions the Andromedans had no way of knowing.

Just as the Andromedans had to have a computer on earth to take day-to-day decisions for them, our genes have to build a brain. But the genes are not only the Andromedans who sent the coded instructions; then are also the instructions themselves. The reason why they cannot manipulate our puppet strings directly is the same: time-lags. Genes work by controlling protein synthesis. This is a powerful way of manipulating the world, but it is slow. It takes months of patiently pulling protein strings to build an embryo. The whole point about behavior, on the other hand, is that it is fast. It works on a time scale not of months but of seconds and fractions of seconds. Something happens in the world, an owl flashes overhead, a rustle in the long grass betrays prey, and in milliseconds nervous systems crackle into action, muscles leap, and someone's life is saved-or lost. Genes don't have reaction times like that. Like the Andromedans, the genes can do only their best *in advance* by building a fast executive computer for themselves, and programming it in advance with rules and "advice" to cope with as many eventualities as they can "anticipate." But life, like the game of chess, offers too many different possible eventualities for all of them to be anticipated. Like the chess programmer, the genes have to "instruct" their survival machines not in specifics, but in the general strategies and tricks of the living trade.

As J. Z. Young has pointed out, the genes have to perform a task analogous to prediction. When an embryo survival machine is being built, the dangers and problems of its life lie in the future. Who can say what carnivores crouch waiting for it behind what bushes, or what fleet-footed prey will dart and zigzag across its path? No human prophet, nor any gene. But some general predictions can be made. Polar bear genes can safely predict that the future of their unborn survival machine is going to be a cold one. They do not think of it as a prophecy, they do not think at all: they just build in a thick coat of hair, because that is what they have always done before in previous bodies, and that is why they still exist in the gene pool. They also predict that the ground is going to be snowy, and their prediction takes the form of making the coat of hair white and therefore camouflaged. If the climate of the Arctic changed so rapidly that the baby bear found itself born into a tropical desert, the predictions of the genes would be wrong, and they would pay the penalty. The young bear would die, and they inside it.

* * *

One of the most interesting methods of predicting the future is simula1. If a general wishes to know whether a particular military plan will be better than alternatives, he has a problem in prediction. There are unknown quantities in the weather, in the morale of his own troops, and in the possible countermeasures of the enemy. One way of discovering whether it is a good plan is to try it and see, but it is undesirable to use this test for all the tentative plans dreamed up, if only because the supply of young men prepared to die "for their country" is exhaustible and the supply of possible plans is very large. It is better to try the various plans out in dummy runs rather than in deadly earnest. This may take the form of full-scale exercises with "Northland" fighting "Southland" using blank ammunition, but even this is expensive in time and materials. Less wastefully, war games may be played, with tin soldiers and little toy tanks being shuffled around a large map.

Recently, computers have taken over large parts of the simulation function, not only in military strategy, but in all fields where prediction of the future is necessary, fields like economics, ecology, sociology, and many others. The technique works like this. A model of some aspect of the world is set up in the computer. This does not mean that if you unscrewed the lid you would see a little miniature dummy inside with the same shape as the object simulated. In the chess-playing computer there is no "mental picture" inside the memory banks recognizable as a chess board with knights and pawns sitting on it. The chess board and its current position would be represented by lists of electronically coded numbers. To us a map is a miniature scale model of a part of the world, compressed into two dimensions. In a computer, a map would more probably be represented as a list of towns and other spots, each with two numbers-its latitude and longitude. But it does not matter how the computer actually holds its model of the world in its head, provided that it holds it in a form in which it can operate on it, manipulate it, do experiments with it, and report back to the human operators in terms which they can understand. Through the technique of simulation, model battles can be won or lost, simulated airliners fly or crash, economic policies lead to prosperity or to ruin. In each case the whole process goes on inside the computer in a tiny fraction of the time it would take in real life. Of course there are good models of the world and bad ones, and even the good ones are only approximations. No amount of simulation can predict exactly what will happen in reality, but a good simulation is enormously preferable to blind trial and error. Simulation could be called vicarious trial and error, a term unfortunately preempted long ago by rat psychologists.

If simulation is such a good idea, we might expect that survival machines would have discovered it first. After all, they invented many of the other techniques of human engineering long before we came on the scene: the focusing lens and the parabolic reflector, frequency analysis of sound waves, servo-control, sonar, buffer storage of incoming information, and countless others with long names, whose details don't matter. What about simulation? Well, when you yourself have a difficult decision to make involving unknown quantities in the future, you do go in for a form of simulation. You imagine what would happen if you did each of the alternatives open to you. You set up a model in your head, not of everything in the world, but of the restricted set of entities which you think may be relevant. You may see them vividly in your mind's eye, or you may see and manipulate stylized abstractions of them. In either case it is unlikely that somewhere laid out in your brain is an actual spatial model of the events you are imagining. But, just as in the computer, the details of how your brain represents its model of the world are less important than the fact that it is able to use it to predict possible events. Survival machines which can simulate the future are one jump ahead of survival machines who can only learn on the basis of overt trial and error. The trouble with overt trial is that it takes time and energy. The trouble with overt error is that it is often fatal. Simulation is both safer and faster.

The evolution of the capacity to simulate seems to have culminated in subjective consciousness. Why this should have happened is, to me, the most profound mystery facing modern biology. There is no reason to suppose that electronic computers are conscious when they simulate, although we have to admit that in the future they may become so. Perhaps consciousness arises when the brain's simulation of the world becomes so complete that it must include a model of itself. Obviously the limbs and body of a survival machine must constitute an important part of its simulated world; presumably for the same kind of reason, the simulation itself could be regarded as part of the world to be simulated. Another word for this might indeed be "self-awareness," but I don't find this a fully satisfying explanation of the evolution of consciousness, and this is only partly because it involves an infinite regress-if there is a model of the model, why not a model of the model of the model? ...

Whatever the philosophical problems raised by consciousness, for the purpose of this story it can be thought of as the culmination of an evolutionary trend towards the emancipation of survival machines as executive decision-takers from their ultimate masters, the genes. Not only are brains in charge of the day-to-day running of survival-machine affairs, they have also acquired the ability to predict the future and act accordingly. They even have the power to rebel against the dictates of the genes, for instance in refusing to have as many children as they are able to. But in this respect man is a very special case, as we shall see.

What has all this to do with altruism and selfishness? I am trying to build up the idea that animal behavior, altruistic or selfish, is under the control of genes in only an indirect, but still very powerful, sense. By dictating the way survival machines and their nervous systems are built, genes exert ultimate power over behavior. But the moment-to-moment decisions about what to do next are taken by the nervous system. Genes are the primary policy-makers; brains are the executives. But as brains became more highly developed, they took over more and more of the actual policy decisions, using tricks like learning and simulation in doing so. The logical conclusion to this trend, not yet reached in any species, would be for the genes to give the survival machine a single overall policy instruction: do whatever you think best to keep us alive.

Selfish Memes

The laws of physics are supposed to be true all over the accessible universe. Are there any principles of biology which are likely to have similar universal validity? When astronauts voyage to distant planets and look for life, they can expect to find creatures too strange and unearthly for us to imagine. But is there anything which must be true of all life, wherever it is found, and whatever the basis of its chemistry? If forms of life exist whose chemistry is based on silicon rather than carbon, or ammonia rather than water, if creatures are discovered which boil to death at -100 degrees centigrade, if a form of life is found which is not based on chemistry at all but on electronic reverberating circuits, will there still be any general principle which is true of all life? Obviously I do not know but, if I had to bet, I would put my money on one fundamental principle. This is the law that all life evolves by the differential survival of replicating entities. The gene, the DNA molecule, happens to be the replicating entity which prevails on our own planet. There may be others. If there are, provided certain other conditions are met, they will almost inevitably tend to become the basis for an evolutionary process.

But do we have to go to distant worlds to find other kinds of replicator and other, consequent, kinds of evolution? I think that a new kind of replicator has recently emerged on this very planet. It is staring us in the face. It is still in its infancy, still drifting clumsily about in its primeval soup, but already it is achieving evolutionary change at a rate which leaves the old gene panting far behind.

The new soup is the soup of human culture. We need a name for the new replicator, a noun which conveys the idea of a unit of cultural transmission, or a unit of *imitation*. "Mimeme" comes from a suitable Greek root, but I want a monosyllable that sounds a bit like "gene." I hope my classicist friends will forgive me if I abbreviate mimeme to *meme*. If it is any consolation, it could alternatively be thought of as being related to "memory," or to the French word *meme*. It should be pronounced to rhyme with "cream."

Examples of memes are tunes, ideas, catch-phrases, clothes fashions, ways of making pots or of building arches. Just as genes propagate themselves in the gene pool by leaping from body to body via sperms or eggs, so memes propagate themselves in the meme pool by leaping from brain to brain via a process which, in the broad sense, can be called imitation. If a scientist hears, or reads about, a good idea, he passes it on to his colleagues and students. He mentions it in his articles and his lectures. If the idea catches on, it can be said to propagate itself, spreading from brain to brain. As my colleague N. K. Humphrey neatly summed up an earlier draft of this chapter: "... memes should be regarded as living structures, not just metaphorically but technically. When you plant a fertile meme in my mind, you literally parasitize my brain, turning it into a vehicle for the meme's propagation in just the way that a virus may parasitize the genetic mechanism of a host cell. And this isn't just a way of talking-the meme for, say, `belief in life after death' is actually realized physically, millions of times over, as a structure in the nervous systems of individual men the world over."

* * *

I conjecture that co-adapted meme-complexes evolve in the same kind of way as co-adapted gene-complexes. Selection favours memes which exploit their cultural environment to their own advantage. This cultural environment consists of other memes which are also being selected. The meme pool therefore comes to have the attributes of an evolutionarily stable set, which new memes find it hard to invade.

I have been a bit negative about memes, but they have their cheerful side as well. When we die there are two things we can leave behind us: genes and memes. We were built as gene machines, created to pass on our genes. But that aspect of us will be forgotten in three generations. Your child, even your grandchild, may bear a resemblance to you, perhaps in facial features, in a talent for music, in the colour of her hair. But as each generation passes, the contribution of your genes is halved. It does not take long to reach negligible proportions. Our genes may be immortal but the *collection* of genes which is any one of us is bound to crumble away. Elizabeth II is a direct descendant of William the Conqueror. Yet it is quite probable that she bears not a single one of the old king's genes. We should not seek immortality in reproduction.

But if you contribute to the world's culture, if you have a good idea, compose a tune, invent a spark plug, write a poem, it may live on, intact, long after your genes have dissolved in the common pool. Socrates may or may not have a gene or two alive in the world today, as G. C. Williams has remarked, but who cares? The meme-complexes of Socrates, Leonardo, Copernicus, and Marconi are still going strong.

Reflections

Dawkins is a master at expounding the reductionist thesis that says life and mind come out of a seething molecular tumult, when small units, accidentally formed, are subjected over and over to the merciless filter of fierce competition for resources with which to replicate. Reductionism sees all of the world as reducible to the laws of physics, with no room for so-called "emergent" properties or, to use an evocative though oldfashioned word, "entelechies"-higher-level structures that presumably cannot be explained by recourse to the laws that govern their parts.

Imagine this scenario: You send your nonfunctioning typewriter (or washing machine or photocopy machine) back to the factory for repair, and a month later they send it back reassembled correctly (as it had been when you sent it in), along with a note saying that they're sorry-all the parts check out fine, but the whole simply doesn't work. This would be considered outrageous. How can every part be perfect if the machine still doesn't work right? Something has to be wrong somewhere! So common sense tells us, in the macroscopic domain of everyday life.

Does this principle continue to hold, however, as you go from a whole to its parts, then from those parts to their parts, and so on, level after level? Common sense would again say yes-and yet many people continue to believe such things as "You can't derive the properties of water from the properties of hydrogen and oxygen atoms" or "A living being is greater than the sum of its parts." Somehow people often envision atoms as simple billiard balls, perhaps with chemical valences but without much more detail. As it turns out, nothing could be further from the truth. When you get down to that very small size scale, the mathemat ics of "matter" becomes more intractable than ever. Consider this passage from Richard Mattuck's text on interacting particles:

A reasonable starting point for a discussion of the many-body problem might be the question of how many bodies are required before we have a problem. Prof. G. E. Brown has pointed out that, for those interested in exact solutions, this can be answered by a look at history. In eighteenth-century Newtonian mechanics, the three-body problem was insoluble. With the birth of general relativity around 1910, and quantum electrodynamics around 1930, the two- and one-body problems became insoluble. And within modern quantum field theory, the problem of zero bodies (vacuum) is insoluble. So, if we are out after exact solutions, no bodies at all is already too many.

The quantum mechanics of an atom like oxygen, with its eight electrons, is far beyond our capability to completely solve analytically. A hydrogen or oxygen atom's properties, not to mention those of a water molecule, are indescribably subtle, and are precisely the sources of water's many elusive qualities. Many of those properties can be studied by computer simulations of many interacting molecules, using simplified models of the atoms. The better the model of the atom, the more realistic the simulation, naturally. **In** fact, computer models have become one of the most prevalent ways of discovering new properties of collections of many identical components, given knowledge only of the properties of an individual component. Computer simulations have yielded new insights into how galaxies form spiral arms, based on modeling a single star as a mobile gravitating point. Computer simulations have shown how solids, liquids, and gases vibrate, flow, and change state, based on modeling a single molecule as a simple electromagnetically interacting structure.

It is a fact that people habitually underestimate the intricacy and complexity that can result from a huge number of interacting units obeying formal rules at very high speeds, relative to our time scale.

Dawkins concludes his book by presenting his own meme about memes-software replicators that dwell in minds. He precedes his presentation of the notion by entertaining the idea of alternate life-support media. One that he fails to mention is the surface of a neutron star, where nuclear particles can band together and disband thousands of times faster than atoms do. In theory, a "chemistry" of nuclear particles could permit extremely tiny self-replicating structures whose high-speed lives would zoom by in an eyeblink, equally complex as their slow earthbound counterparts. Whether such life actually exists-or whether we could ever find out, assuming it did-is unclear, but it gives rise to the amazing idea of an entire civilization's rise and fall in the period of a few earth days-a super-Lilliput! The selections by Stanislaw Lem in this book all share this quality; see especially selection 18, "The Seventh Sally."

We bring this weird idea up to remind the reader to keep an open mind about the variability of media that can support complex lifelike or thoughtlike activity. This notion is explored slightly less wildly in the following dialogue, in which consciousness emerges from the interacting levels of an ant colony.

D. R. H.

On Debating Religion The "know-nothings", the "know-alls", and the "no-contests" Dec/94

A lecture by Richard Dawkins)

Richard Dawkins, well-known for his books on evolution, took part in a debate with the Archbishop of York, Dr John Habgood, on the existence of God at the Edinburgh science festival last Easter. [Easter '92 ed.] The science correspondent of The Observer reported that the "withering" Richard Dawkins clearly believed the "God should be spoken of in the same way as Father Christmas or the Tooth Fairy". He [the correspondent] overheard a gloomy cleric comment on the debate: "That was easy to sum up. Lions 10, Christians nil".

Religious people split into three main groups when faced with science. I shall label them the "know-nothings", the "know-alls", and the "no-contests". I suspect that Dr John Habgood, the Archbishop of York, probably belongs to the third of these groups, so I shall begin with them.

The "no-contests" are rightly reconciled to the fact that religion cannot compete with science on its own ground. They think there is no contest between science and religion, because they are simply about different things. the biblical account of the origin of the universe (the origin of life, the diversity of species, the origin of man) -- all those things are now known to be untrue.

The "no-contests" have no trouble with this: they regard it as naive in the extreme, almost bad taste to ask of a biblical story, is it true? True, they say, true? Of course it isn't true in any crude literal sense. Science and religion are not competing for the same territory. They are about different things. They are equally true, but in their different ways.

A favourite and thoroughly meaningless phrase is "religious dimension". You meet this in statements such as "science is all very well as far as it goes, but it leaves out the religious dimension".

The "know-nothings", or fundamentalists, are in one way more honest. They are true to history. They recognize that until recently one of religion's main functions was scientific: the explanation of existence, of the universe, of life. Historically, most religions have had or even been a cosmology and a biology. I suspect that today if you asked people to justify their belief in God, the dominant reason would be scientific. Most people, I believe, think that you need a God to explain the existence of the world, and especially the existence of life. They are wrong, but our education system is such that many people don't know it.

They are also true to history because you can't escape the scientific implications of religion. A universe with a God would like quite different from a universe without one. A physics, a biology where there is a God is bound to look different. So the most basic claims of religion are scientific. Religion is a scientific theory.

I am sometimes accused of arrogant intolerance in my treatment of creationists. Of course arrogance is an unpleasant characteristic, and I should hate to be thought arrogant in a general way. But there are limits! To get some idea of what it is like being a professional student of evolution, asked to have a serious debate with creationists, the following comparison is a fair one. Imagine yourself a classical scholar who has spent a lifetime studying Roman history in all its rich detail. Now somebody comes along, with a degree in marine engineering or mediaeval musicology, and tries to argue that the Romans never existed. Wouldn't you find it hard to suppress your impatience? And mightn't it look a bit like arrogance?

My third group, the "know-alls" (I unkindly name them that because I find their position patronising), think religion is good for people, perhaps good for society. Perhaps good because it consoles them in death or bereavement, perhaps because it provides a moral code.

Whether or not the actual beliefs of the religion are true doesn't matter. Maybe there isn't a God; we educated people know there is precious little evidence for one, let alone for ideas such as the Virgin birth or the Resurrection. but the uneducated masses need a God to keep them out of mischief or to comfort them in bereavement. The little matter of God's probably non-existence can be brushed to one side in the interest of greater social good. I need say not more about the "know-alls" because they wouldn't claim to have anything to contribute to scientific truth.

Is God a Superstring?

I shall now return to the "no-contests". The argument they mount is certainly worth serious examination, but I think that we shall find it has little more merit than those of the other groups.

God is not an old man with a white beard in the sky. Right then, what is God? And now come the weasel words. these are very variable. "God is not out there, he is in all of us." God is the ground of all being." "God is the essence of life." "God is the universe." "Don't you believe in the universe?" "Of course I believe in the universe." "Then you believe in God." "God is love, don't you believe in love?" "Right, then you believe in God?"

Modern physicists sometimes wax a bit mystical when they contemplate questions such as why the big bang happened when it did, why the laws of physics are these laws and not those laws, why the universe exists at all, and so on. Sometimes physicists may resort to saying that there is an inner core of mystery that we don't understand, and perhaps never can; and they may then say that perhaps this inner core of mystery is another name for God. Or in Stephen Hawkings's words, if we understand these things, we shall perhaps "know the mind of God."

The trouble is that God in this sophisticated, physicist's sense bears no resemblance to the God of the Bible or any other religion. If a physicist says God is another name for Planck's constant, or God is a superstring, we should take it as a picturesque metaphorical way of saying that the nature of superstrings or the value of Planck's constant is a profound mystery. It has obviously not the smallest connection with a being capable of forgiving sins, a being who might listen to prayers, who cares about whether or not the Sabbath begins at 5pm or 6pm, whether you wear a veil or have a bit of arm showing; and no connection whatever with a being capable of imposing a death penalty on His son to expiate the sins of the world before and after he was born.

The Fabulous Bible

The same is true of attempts to identify the big bang of modern cosmology with the myth of Genesis. There is only an utterly trivial resemblance between the sophisticated conceptions of modern physics, and the creation myths of the Babylonians and the Jews that we have inherited.

What do the "no-contests" say about those parts of scripture and religious teaching that once-upon-a-time would have been unquestioned religious and scientific truths; the creation of the world the creation of life, the various miracles of the Old and New Testaments,, survival after death, the Virgin Birth? These stories have become, in the hands of the "no-contests", little more than moral fables, the equivalent of Aesop of Hans Anderson. There is nothing wrong with that, but it is irritating that

they almost never admit this is what they are doing.
For instance, I recently heard the previous Chief Rabbi, Sir Immanuel Jacobovits, talking about the evils of racism. Racism is evil, and it deserves a better argument against it that the one he gave. Adam and Eve, he argued, were the ancestors of all human kind. Therefore, all human kind belongs to one race, the human race.
What are we going to make of an argument like that? The Chief Rabbi is an educated man, he obviously doesn't believe in Adam and Eve, so what exactly did he think he was saying?
He must have been using Adam and Eve as a fable, just as one might use the story of Jack the Giantkiller or Cinderella to illustrate some laudable moral homily.
I have the impression that clergymen are so used to treating the biblical stories as fables that they have forgotten the difference between fact and fiction. It's like the people who, when somebody dies on The Archers, write letters of condolence to the others.
Inheriting Religion
As a Darwinian, something strikes me when I look at religion. Religion shows a pattern of heredity which I think is similar to genetic heredity. The vast majority of people have an allegiance to one particular religion. there are hundreds of different religious sects, and every religious person is loyal to just one of those.
Out of all of the sects in the world, we notice an uncanny coincidence: the overwhelming majority just happen to choose the one that their parents belong to. Not the sect that has the best evidence in its favour, the best miracles, the best moral code, the best cathedral, the best stained glass, the best music: when it comes to choosing from the smorgasbord of available religions, their potential virtues seem to count for nothing, compared to the matter of heredity.
This is an unmistakable fact; nobody could seriously deny it. Yet people with full knowledge of the arbitrary nature of this heredity, somehow manage to go on believing in their religion, often with such fanaticism that they are prepared to murder people who follow a different one.
Truths about the cosmos are true all around the universe. They don't differ in Pakistan, Afghanistan, Poland, or Norway. Yet, we are apparently prepared to accept that the religion we adopt is a matter of an accident of geography.
If you ask people why they are convinced of the truth of their religion, they don't appeal to heredity. Put like that it sounds too obviously stupid. Nor do they appeal to evidence. There isn't any, and nowadays the better educated admit it. No, they appeal to faith. Faith is the great cop-out, the great excuse to evade the need to think and evaluate evidence. Faith is belief in spite of, even perhaps because of, the lack of evidence. The worst thing is that the rest of us are supposed to respect it: to treat it with kid gloves.
If a slaughterman doesn't comply with the law in respect of cruelty to animals, he is rightly prosecuted and punished. but if he complains that his cruel practices are necessitated by religious faith, we back off apologetically and allow him to get on with it. Any other position that someone takes up can expect to be defended with reasoned argument. Faith is allowed not to justify itself by argument. Faith must be respected; and if you don't respect it, you are accused of violating human rights.
Even those with no faith have been brainwashed into respecting the faith of others. When so-called Muslim community leaders go on the radio and advocate the killing of Salman Rushdie, they are clearly committing incitement to murder--a crime for which they would ordinarily be prosecuted and possibly imprisoned. But are they arrested? They are not, because our secular society "respects" their faith, and sympathises with the deep "hurt" and "insult" to it.
Well I don't. I will respect your views if you can justify them. but if you justify your views only by saying you have faith in them, I shall not

respect them.

Improbabilities

I want to end by returning to science. It is often said, mainly by the "no-contests", that although there is no positive evidence for the existence of God, nor is there evidence against his existence. So it is best to keep an open mind and be agnostic.

At first sight that seems an unassailable position, at least in the weak sense of Pascal's wager. But on second thoughts it seems a cop-out, because the same could be said of Father Christmas and tooth fairies. There may be fairies at the bottom of the garden. There is no evidence for it, but you can't prove that there aren't any, so shouldn't we be agnostic with respect to fairies?

The trouble with the agnostic argument is that it can be applied to anything. There is an infinite number of hypothetical beliefs we could hold which we can't positively disprove. On the whole, people don't believe in most of them, such as fairies, unicorns, dragons, Father Christmas, and so on. But on the whole they do believe in a creator God, together with whatever particular baggage goes with the religion of their parents.

I suspect the reason is that most people, though not belonging to the "know-nothing" party, nevertheless have a residue of feeling that Darwinian evolution isn't quite big enough to explain everything about life. All I can say as a biologist is that the feeling disappears progressively the more you read about and study what is known about life and evolution.

I want to add one thing more. The more you understand the significance of evolution, the more you are pushed away from the agnostic position and towards atheism. Complex, statistically improbable things are by their nature more difficult to explain than simple, statistically probable things.

The great beauty of Darwin's theory of evolution is that it explains how complex, difficult to understand things could have arisen step by plausible step, from simple, easy to understand beginnings. We start our explanation from almost infinitely simple beginnings: pure hydrogen and a huge amount of energy. Our scientific, Darwinian explanations carry us through a series of well-understood gradual steps to all the spectacular beauty and complexity of life.

The alternative hypothesis, that it was all started by a supernatural creator, is not only superfluous, it is also highly improbable. It falls foul of the very argument that was originally put forward in its favour. This is because any God worthy of the name must have been a being of colossal intelligence, a supermind, an entity of extremely low probability--a very improbable being indeed.

Even if the postulation of such an entity explained anything (and we don't need it to), it still wouldn't help because it raises a bigger mystery than it solves.

Science offers us an explanation of how complexity (the difficult) arose out of simplicity (the easy). The hypothesis of God offers no worthwhile explanation for anything, for it simply postulates what we are trying to explain. It postulates the difficult to explain, and leaves it at that. We cannot prove that there is no God, but we can safely conclude the He is very, very improbable indeed.

This was a lecture by Richard Dawkins extracted from The Nullifidian (Dec 94)

Trial by Jury - Richard Dawkins

Trial by Jury by Richard Dawkins. Published as “Three herring gull chicks . . . the reason juries don’t work” in The Observer (London), Sunday November 16, 1997.

Trial by jury must be one of the most conspicuously bad good ideas anyone ever had. Its devisers can hardly be blamed. They lived before the principles of statistical sampling and experimental design had been worked out. They weren’t scientists. Let me explain using an analogy. And if, at the end, somebody objects to my argument on the grounds that humans aren’t herring gulls, I’ll have failed to get my point across. Adult herring gulls have a bright yellow bill with a conspicuous red spot near the tip. Their babies peck at the red spot, which induces the parents to regurgitate food for them. Niko Tinbergen, Nobel-Prizewinning zoologist and my old maestro at Oxford, offered naive young chicks a range of cardboard dummy gull heads varying in bill and spot colour, and shape. For each colour, shape or combination, Tinbergen measured the preferences of the baby chicks by counting their pecks in a standard time. The idea was to discover whether naive gull chicks are born with a built-in preference for long yellow things with red spots. If so, this would suggest that genes equip the young birds with detailed prior knowledge of the world in which they are about to hatch – a world in which food comes out of adult herring gull beaks.

Never mind the reason for the research, and never mind the conclusions. Consider, instead, the methods you must use, and the pitfalls you must avoid, if you want to get a correct result in any such experiment. These turn out to be general principles which apply to human juries as strongly as to gull chicks.

First, you obviously must test more than one chick. It could be that some chicks are red-biased, others blue-biased, with no tendency for herring gull chicks in general to share the same favourite colour. So, by picking out a single chick, you are measuring nothing more than individual bias. It is no answer to this objection that our chick may have given hundreds more pecks to one colour than to the other. A chick might begin by choosing any old colour at random, but once he has chosen he gets ‘locked on’ to that colour and hammers away at it, giving the other colours no chance. The essential problem here is that successive pecks, however numerous, are not ‘independent data’.

So, we must test more than one chick. How many? Is two enough? No, nor is three, and now we must start to think statistically. To make it simple, suppose that in a particular experiment we are comparing only red spots versus blue spots, both on a yellow background, and always presented simultaneously. If we test just two chicks separately, suppose the first chick chooses red. It had a 50% chance of doing so, at random. Now the second chick also happens to choose red. Again, the odds were 50% that it would do so at random, even if it were colourblind. There’s a 50% chance that two randomly choosing chicks will agree (half of the four possibilities: red red, red blue, blue red, blue blue). Three chicks aren’t enough either. If you write down all the possibilities, you’ll find that there’s a 25% chance of a unanimous verdict, by luck alone. Twenty five percent, as the odds of reaching a conclusion for the wrong reason, is unacceptably large.

How about twelve good chicks and true? Now you’re talking. If twelve chicks are independently offered a choice between two alternatives, the odds that they will all reach the same verdict by chance alone are satisfyingly low, only one in 1024.

But now suppose that, instead of testing our twelve chicks independently, we test them as a group. We take a maelstrom of twelve cheeping chicks and lower into their midst a red spotted dummy and a blue spotted dummy, each fitted with an electrical device for automatically tallying pecks. And suppose that the collective of chicks registers 532 pecks at red and zero at blue. Does this massive disparity show that herring gull chicks, in general, prefer red? Absolutely not. The pecks are not independent data. Chicks could have a strong tendency to imitate one another (as well as imitate themselves in lock-on effects). If one chick just happened to peck at red first, others might copy him and the whole company of chicks join in a frenzy of imitative pecking. As a matter of fact this is precisely what domestic chicken chicks do, and gull chicks are very likely the same. Even if not, the principle remains that the data are not independent and the experiment is therefore invalid. The twelve chicks are strictly equivalent to a single chick, and their summed pecks amount to only a single independent result.

Turning to courts of law, why are twelve jurors preferred to a single judge? Not because they are wiser, more knowledgeable or more practised in the arts of reasoning. Certainly not, and with a vengeance. Think of the astronomical damages awarded by juries in footling libel cases. Think how juries bring out the worst in histrionic, gallery-playing lawyers. Twelve jurors are preferred to one judge only because they are more numerous. Letting a single judge decide a verdict would be like letting a single chick speak for the whole herring gull species. Twelve heads are better than one, because they represent twelve assessments of the evidence. But for this argument to be valid, the twelve assessments really have to be independent. And of course they are not. Twelve men and women locked in a jury room are like our clutch of twelve gull chicks. Whether they actually imitate each other like chicks, they might. That is enough to invalidate the principle by which a jury might be preferred over a single judge.

In practice, as is well documented and as I remember from the three juries that it has been my misfortune to serve on, juries are massively swayed by one or two vocal individuals. There is also strong pressure to conform to a unanimous verdict, which further undermines the principle of independent data. Increasing the number of jurors doesn't help, or not much (and not at all in strict principle). What you have to increase is the number of independent verdict-reaching units.

Oddly enough, the bizarre American system of televising trials opens up a real possibility of improving the jury system. By the end of trials such as those of Louise Woodward or O. J. Simpson, literally thousands of people around the country have attended to the evidence as assiduously as the official jury. A mass phone-in might produce a fairer verdict than a jury. But unfortunately journalistic discussion, radio talk-shows, and ordinary gossip would violate the Principle of Independent Data and we'd be back where we started. The broadcasting of trials, in any case, has horrible consequences. In the wake of Louise Woodward's trial, the Internet seethes with ill-spelled and ungrammatical viciousness, the cheque-book journalists are queuing up, and the unfortunate Judge Zobel has had to change his telephone number and employ a bodyguard. So, how can we improve the system? Should twelve jurors be locked in twelve isolation chambers and their opinions separately polled so that they constitute genuinely independent data? If it is objected that some would be too stupid or inarticulate to reach a verdict on their own, we are left wondering why such individuals are allowed on a jury at all.

Perhaps there is something to be said for the collective wisdom that emerges when a group of twelve people thrash out a topic together, round a table. But this still leaves the principle of independent data unsatisfied. Should all cases be tried by two separate juries? Or three? Or twelve? Too expensive, at least if each jury has twelve members. Two juries of six members, or three juries of four members, would probably be an improvement over the present system. But isn't there some way of testing the relative merits of such alternative options, or of comparing the merits of trial by jury versus trial by judge?

Yes, there is. I'll call it the Two Verdicts Concordance Test. It is based on the principle that, if a decision is valid, two independent shots at making it should yield the same result. Just for purposes of the test, we run to the expense of having two juries, listening to the same case and forbidden to talk to members of the other jury. At the end, we lock the two juries in two separate jury rooms and see if they reach the same verdict. If they don't, nothing can be proved beyond reasonable doubt, and this would cast reasonable doubt on the jury system itself. To make the experimental comparison with Trial by Judge, we need two experienced judges to listen to the same case, and require them too to reach their separate verdicts without talking to each other. Whichever system, Trial by Jury or Trial by Judge, yields the higher score of agreements over a number of trials is the better system and might even be accredited for future use with some confidence. Would you bet on two independent juries reaching the same verdict in the Louise Woodward case? Could you imagine even one other jury reaching the same verdict in the O. J. Simpson case? Two judges, on the other hand, seem to me rather likely to score well on the concordance test. And should I be charged with a serious crime here's how I want to be tried. If I know myself to be guilty, I'll go with the loose cannon of a jury, the more ignorant, prejudiced and capricious the better. But if I am innocent, and the ideal of multiple independent decision-takers is unavailable, please give me a judge. Preferably Judge Hiller Zobel.

Sarah Bowling
December 12, 2004
Period 6

Anatomy Book Assignment

This book, The Old Man Who Mistook His Wife for a Hat by Oliver Sacks, has many different stories that include severe analysis of many brain disorders different scientists and doctors have discovered and studied. Many of the different scenarios have to do with a loss of memory in different parts of the brain. In the first story a teacher was taken in to the doctor because he had a loss of memory and could not recognize anyone anymore. He would only remember your name if you had a specific feature that really stood out from the rest. Another man that was observed could only remember his past up to a certain point in his life. However, now in his everyday life he losses his memory every few minutes and basically starts over. He doesn’t even come to realize that he has aged well over thirty years. When he is forced to look into a mirror he freaks out and losses all state of mind in confusion. This loss was due to drinking too much alcohol in his younger years that damaged his mammillary bodies. This is very rare among heavy drinkers. Another one describes the life of a “disembodied” woman. This happens to people with severe sensory neuronopathies. Basically this woman had no control over her own body. In order for her to move a certain body part the way she wanted she would have to concentrate very had and visually watch it move. There was no way of it moving on its own. The second part of this book told stories of patients who had excesses in the brain. One of the stories titled “Witty Ticcy Ray” told of a grown man suffering with Tourette’s syndrome. Well everyone figured he was suffering but really it gave him the personality he has today that he has learned to live with. He really wasn’t suffering until it got too out of hand, but that was only at times. Ray loved his life with Tourette’s syndrome. It made him exciting and fun to be around, or so he thought. However, he was willing to admit that he should seek help to find medicine to help contain this excitement. Once on his medication he hated it. He was slow all the time and never quick or witty like he used to be so he immediately went back to his doctor. His doctor and him compromised that if he took his medicine during the week then on the weekends (Saturday and Sunday) he could be his old self again off of his medicine. Another part of this book told stories of certain transports of the brain. One of the stories had to do with two old women in a nursing home that complained of hearing things inside their heads that no one else could hear besides them. For example, one of them would repeatedly hear Irish songs from her past and have frequent flashbacks from her childhood that she could never remember until now in her late eighties. What was happening was inside her brain she was having ‘experiential’ seizures that caused all of these things inside her head to happen.

Overall I think this book had to do with anatomy in different ways. It went in great detail over different parts on the brain the doctors had focused on for their many patients. For the most part that was the only part of the body these different stories focused on. However, one of them had to do with a man’s leg that he thought was detached from his body. But in reality was very much still attached however was numb and couldn’t be felt in any way.

I thought the book was very interesting. I could tell by reading it that it was all fact and they could back up everything they were studying. The only parts I didn't like were when he would write using so many different scientific words at a time that it got hard to read and understand. But, he did write in laymen's terms for the most part. By writing this book the author was trying to achieve an understanding and a realization of all of the different losses and diseases that can take part in your brain. He achieved this because anyone that reads this book will definitely have a better understands of this whole other world he is living in. From this book I have learned of all of these different cases of the brain he has worked with in his life. For example, different types of losses, excesses, and transports of the brain he has observed. I thoroughly enjoyed this book. It was very interesting and I learned many things about what really goes on inside the head and brain.

Carey Glasheen

Oliver Sacks' autobiographical A Leg to Stand On is about his personal experience while hiking up a mountain in Norway (Hardanger Fjord) by himself. It begins with him starting the climb early in the morning in hopes to reach the top by noon. While in the process, he reaches a point where a sign reads, "BEWARE OF THE BULL!" in Norwegian. He is not sure to take this sign literal or if it is just a joke. However, he brushes it off and proceeds. Once beyond a huge boulder he sees the bull, which looks monstrous and devilish. He therefore, turns around and runs as fast and as far from the bull as possible. During this he falls and injures his left leg badly. Sacks realizes he has a neurological problem due to the fact that he feels his leg has been disconnected from his body. He seems to not be able to "locate it." Once the huntsman rescues him, Sacks' situation becomes somewhat awkward for him because he is use to being the doctor rather than the patient. After meeting amazing, charismatic doctors, Sacks is reassured about his operation. He spends several weeks in the hospital recovering while he enjoys frequent visits from friends and family. Throughout his recovery process Sacks becomes more sensitive to his patients because he has been placed in their positions. This helps Sacks understand their sides better.

Oliver Sacks is known for his intelligent informative, yet entertaining novels. A Leg to Stand On is a true novel reaching beyond just an experience and somewhat into the world of anatomy and physiology. All throughout the novel are statements expressing the nature of the body. From physical to mental, Sacks surpasses any expectations. For example, his leg, which he injures in the process of escaping a bull in the mountains of Norway, becomes paralyzed (physically). However, Sacks also remembers feeling separated from it mentally also. He feels as if it is no longer a part of his body. Apparently, it is a neurological problem that surfaces. Vertebrate anatomy has much to do with the skeletal system and also including the spinal system. In the novel, after being rescued from the mountains, Sacks is given a general anesthesia, which puts you completely "asleep" so you do not feel or see anything during surgery. However Sacks, being a doctor, knows exactly what it is and insists he should be given a spinal anesthesia. However, the nurse follows through with her orders because it is prevalent that if given the spinal, Sacks would see everything happening and want to ask questions about the procedure and such. The doctors knew better; Sacks would have been nothing but a distraction. Recovery was a struggle for Sacks. Due to thinking his leg was made of wood for so long, Sacks forgets how to walk. He underwent much therapy to help him overcome this dilemma. Much of the novel focuses on his mental disorder to get over his ideas of his dislocated leg. His doctor refuses to believe that he has a mental disorder thus he must conquer it all alone.

I actually really enjoyed this book. I was definitely skeptical of reading it because I did not think it would be very interesting, but I was proven wrong. Usually I don't read books assigned in school and somehow figure out something to get around it, but this year it has been the total opposite. Although I did not understand all of the science and medical terms, I understood the majority and more important parts. Oliver Sacks has a true talent to be able to put a story, true or fictional, and also make it informative. I've learned a lot from this book by simply reading it and looking up words I stumbled upon that confused me. I think Sacks' purpose of writing this was to help him recover from the injury by describing into words his experience. Also, he wanted to share what it is like to be on the patients' side of a patient-doctor relationship. He finally was able to comprehend what it's like for the person seeking help through a physician's aid. Sacks absolutely achieved his purpose. He's found that not only physical needs are met by doctors but also mental and spiritual. Sacks did not paint a pretty story and change things around to make them more appealing. He simply stated what happened, how it happened, and the results. Sacks did not even hold back on language. There are many cases where foul language is said, but that's okay, because that way the reader truly sees and feels the pain of certain situations. I do not think I could call anything in the novel a weakness because this was his personal experience and to try to alter anything would change the effectiveness. A Leg to Stand On is important because it's not your typical book read in school about history or literature, therefore you can actual enjoy it. It is not only entertaining but is also something you can learn things from. The reader is put into his experience and able to understand his side of being in a situation for the first time. It is interesting to hear how he handles himself in unfamiliar territory. If I could ask the author anything, I think I would just ask about what was running through his mind when he found out the warning sign of the bull turned out to be true. Also, I think I'd ask if he treats his patients any differently due to his experiences as the patient rather than the doctor.

Michelle Robinson
December 13, 2004
Period 2

The book Seeing Voices: A Journey through the World of the Deaf, by Oliver Sacks is an informational book about the lives of deaf people and the way they experience life. The book discusses how deaf people have been treated in the past and how many of them are struggling to gain acceptance from the "normal" world. Oliver Sacks also introduces the many people he has met and learned about throughout his research of the deaf. The extensive footnotes used show how Sacks related almost every subject within the book to authors, professors and historic events that he encountered or studied. He describes the two types of people, Preligually deaf and Postligually deaf and repeatedly refers to the different challenges in life that each type of deaf individual faces. He explains the similarities and differences of sign language to auditory language and attempts to disprove the inaccuracy that deaf people can communicate with others all over the world. Most people do not know that there are more than fifty native sign languages. The final chapter of the book discusses a historical event that I had never been taught or heard of before. In March 1988 the students of a deaf institution, Gallaudet University, organized a marched to the Capitol because of the way they were treated within their school and the fact that the deaf university never had a deaf president. They felt members of the administration treated them as pets and often referred to them as disabled or abnormal individuals. The students gained more than a thousand supporters from other deaf schools and deaf people. In the end the university's board met and announced a new president, a deaf man who could relate to the students and their concerns. Just as the Civil Rights Movement is a milestone in history to blacks, this march is an equality movement milestone to many deaf people around the United States.

This book relates to physiology due to its references to the brain, however there is only one chapter within the book that discusses the brain and its relation to how deaf people function and interact. Deaf people use sign language to communicate and even though it is visual rather than auditory the brain sees it as a language and it is processed in the left hemisphere of the brain. In this class we have studied the lobes of the brain but we have not gone as in depth as the book does. "The fact that Sign is based here in the left hemisphere, despite its spatial organization, suggests that there is a representation of "linguistic" space in the brain completely different from that of ordinary, "topographic" space" (Sacks 95). Basic elements of physiology directly relate to the functions of the brain and how the brain controls the body. However, to date in class we have only studied parts of the skull and identified the lobes of the brain. The correlation between grammatical language and how certain parts of the brain are developed are discussed within the book. Neurologist Helen Neville says, "If language experience does impact cerebral development, then aspects of cerebral specialization ought to be different in deaf and hearing subjects when they read

English" (Sacks 109). After conducting tests she later concludes that her hypothesis stated above is correct. "Grammatical competence is necessary and sufficient for left hemisphere specialization-if it occurs early" (Sacks 109). We have already briefly discussed and identified the lobes of the brain and hopefully as the year progresses we will learn more of the functions of each lobe of the brain. The brain is the center of all activity of our bodies and can reveal many things about ourselves. In the book the reactions of the brain are discussed. The study that took place proves the longtime revelation that if you lose one sense the other four become keener. "Deaf signers show greater speed of reaction to these stimuli-and this goes with an increase of evoked potentials in the occipital lobes of the brain, the primary reception areas for vision…and seem to reflect a compensatory phenomenon-the enhancement of one sense in place of another" (Sacks 101). Although there was only a chapter in the book about the brain, the content discussed in the book accurately relates to certain subject in this class.

Oliver Sacks displayed his articulate writing abilities through this book. Though it was not one of my favorites, it kept me involved with its interesting facts and studies that otherwise I would not have known. The book taught people about the struggles of being deaf and the prejudices with which deaf persons are faced. Deaf people are normal just like hearing people and they need to be treated that way. The average American probably has no idea that deaf people led a march to the Capitol in 1988 and that deaf people have been discriminated for hundreds of years. Sacks wrote this book to teach people those facts and give them insight to another "world" that many have never even acknowledged. He wanted people to know about the deaf community and how they live similar lives with a few accommodations to help them succeed and be treated as equals.

"The study of the deaf shows us that much of what is distinctively human in us-our capacities for language, for thought, for communication, and culture-do not develop automatically in us, are not just biological functions, but are equally, social and historical in origin; that they are a gift- the most wonderful of gifts-from one generation to another"(Sacks 6).

Sacks achieved what he hoped, he opened people's eyes. If not everyone, he opened my eyes to new thoughts and perceptions of the world around me. The book is strong because of its citations from hundreds of different professors, studies, and events. It helps to show that Sacks took pride in his writings and wanted to prove his knowledge and accuracy of each subject. The only weakness within the book is how it shifts from topic to topic at times. That causes a bit of confusion and forces the reader to stay focused. The book's importance is that it serves an eye opener and realization to the other people around you and that their lives may not be the same. Because of that, we must accept all people and their differences. The only question I have for Mr. Sacks is what impelled him to write this book and perform all the research that took place because I know it was very time consuming.

Emily Smithson
December 5, 2004 Period 2

The Man Who Mistook His Wife for a Hat

Describing a disease to someone does not have the same effect unless one connects it to a personal experience. When a name and story is related to a disease it truly becomes heartbreaking. In the book, The Man Who Mistook His Wife for a Hat Dr. Oliver Sacks describes his many interactions with patients with brain defects.

Many times even the most successful people have life changing diseases. A prime example is the story of a talented musician and teacher named Dr. P. His life seemed to be going normally until suddenly he began to forget who his students were. The students had to speak before he recognized them. At first, people believed it was just a problem with his eyes, so he visited an optometrist, but the doctor discovered nothing abnormal. During Dr. P's first visit with Dr. Sacks, everything seemed to be fine until he was asked to put his shoe back on. Confused by the request, Dr. P replied that he was already wearing his shoe. Also, at the end of the examination, Dr. P grabbed his wife's head instead of his hat. In later examinations it was discovered that he was unable to recognize anyone, even his own family, by their faces. The only way Dr. P continued a daily routine was by singing. If something or someone interrupted him he became completely disoriented and lost. Music was what kept him functioning, and he continued to sing and teach until the day he died.

It is hard to imagine living a life without any meaning or purpose and in many ways being completely lost. William Thompson had no memory or true purpose in life, so he made up stories to satisfy his loss. When surrounded by a group of people or even an individual, he could go on for hours about his amazing adventures and encounters with different people. Sadly, none of the stories he told were true. It was almost as if he was trying to cover-up for his loss of memory. After a few seconds all that he had previously stated was completely forgotten, and he re-invented new stories to entertain both himself and others. At first, when meeting William, he seems like an interesting adventurous man, until one realizes that he never stopped talking. The reason for his continuous chatter was because he cannot repair his mental loss no matter how hard he tries. Wandering alone in the garden is the only time that William will remain silent. If people are not around him then he has no reason to prove his identity. His communication with nature itself his the only time he is truly at harmony.

People that hear voices in their heads are assumed to be crazy, but what if someone heard actual songs. Mrs. O'C woke up in the middle of the night from the sound of her childhood Irish songs. She assumed it was someone's radio until she discovered no radio was on. After a few days the songs became infrequent and softer, but Dr. Sacks performed an electroencephalogram to observe the temporal lobes. After the test it was confirmed that she was having temporal lobe seizures, which caused Irish songs to repeat in her head. Surprisingly, she welcomed the songs as a flashback to her youth. A year later another woman, Mrs. O'M, in the same home, complained of hearing songs in her head. Unlike Mrs. O'C she had no real connection to the songs and her songs were even louder and more intense. When the electroencephalogram was performed it showed high voltage in both her temporal lobes. In order to get rid of the obnoxious tunes Mrs. O'M took anticonvulsants, which in time stopped the music. Although both cases were similar it is interesting how one woman benefited from the music while the other was driven insane.

Depending on where someone is situated can cause them to have many different personalities. Rebecca was a nineteen-year-old girl who acted as if she was little child. Simple tasks such as putting a key into a lock took her hours to figure out. Everyone had stereotyped her as being a retard or a moron. When Rebecca was tested in Dr. Sacks office she failed horribly and everything predicted to be wrong with her was. Her inability to read and her IQ of 60 made her seem like a complete waste. One day Dr. Sacks observed Rebecca sitting on a bench looking at nature. Instead of the clumsy girl he had seen in the clinic, Rebecca sat with perfect posture. As he approached her, she began commenting poetically about the beautiful outdoors. When she was taken away from the clinic she acted like a completely different sophisticated individual. Unfortunately, a few months later, Rebecca's Grandmother passed away, but surprisingly she dealt with it like a mature adult. Rebecca was a typical patient at the clinic so she was forced to attend certain classes, but instead of being beneficial to her they took her away from her true meaning for life. She approached Dr. Sacks about the classes and suggested that taking a theatre class would be much more beneficial. Today when one observes Rebecca onstage, it is hard to imagine that at one time she was tested for disabilities.

The Man Who Mistook His Wife for a Hat is centered on the physiology of the brain. In every story Dr. Sacks describes different kinds of effects of the brain and how they changes people's lifestyle. This class is primarily focused on learning the different parts of organisms, but we also focus on the functions of the different parts of the bodies, which deals with physiology. In the third semester when we learn about the brain and brain awareness week, this book will be extremely helpful. Also, during many of his stories, Dr.Sacks mentions different parts of the bodies that were discussed in class. For example, when describing the position of a man's back he uses the term, latisssimus dorsi. Earlier in the year this term appeared as the upper back muscle of a frog.

Many people are completely oblivious to the different diseases that affect the brain. Oliver Sacks is able to make people aware of the diseases by relating them to individual stories. His book would have been far less successful if he had simply listed the diseases, but instead he makes it much more personable to everyone. Also, he does an amazing job of making the book readable without the complicated medical terminology. It allows people with no medical background to become educated in neurology. One criticism of the book are the lengthy postscripts, which dragged on the story and took away from the effect of the disease. One does not realize how many defects actually occur in the brain, and really without any apparent reason. This book makes people realize that many times people are not born with the diseases that take over their brain and completely change their lifestyle. Before passing a judgment about the way someone acts or looks, one most take into consideration that they may have been normal at one time and do not choose to act the way they do. It must get depressing for Oliver Sacks to meet all these people who have lost all that they live for. He must get disheartened at the idea that many times he can't do anything to help these innocent people. How does a man stay sane with so many people relying on him to make everything better?

Kelsey Vonier
December 8,2004
Period 6

Vertebrate Anatomy and Physiology Book Assignment

From the very first page of Complications: A Surgeon's Note on an Imperfect Science, I knew that this was a book for me. Right from the beginning the author opened with a story. Before I had feared that it would just be another dry, nonfiction school book, but Gawande's suspenseful anecdotes kept my interest throughout the book.

The first section of this book, titled "Fallibility," took an in-depth look at the residency of a surgeon through a surgeon's eyes. Everything from the first week of residency when a surgeon does only the most basic of procedures, to the end when they are practically doing everything imaginable, was discussed. Landmark firsts such as going to the first medical conference and the dreams of a surgeon as he strived for perfection were also examined.

As the book continued, so did the life of the surgeon. Soon after entering residency, he discovered that it was a very grey world as far as medicine goes. In numerous cases that he mentioned, there were people who were experiencing unexplainable sicknesses and pains that no one could figure out. Many of the patients suffered from things that most people never even think about, such as uncontrollable blushing. From the man who had such painful back aches that he couldn't get out of bed, to the man who had eaten himself into a deadly obesity, the one common thing that ran throughout all of the cases was that mental issues were the main suspects of the problem. As stated by Gawande, "all pain is in the head" (125). This idea was later followed up with the explanation that "no physical pain of any kind is needed to make the pain system go haywire" (125).

Finally, Gawande made note of patient-doctor relationships and the uncertainties of how decisions should be made. In many cases, the process was far more complicated than the simple question of whether or not to do the surgery. Many other factors such as the patient's desires also came into play. At this point, Gawande also took the chance to observe different kinds of patients and their families and even did follow up checks after each surgery to see how everything had turned out. By doing this he was able to see if the choices that he had made really had been the right ones. In one case he looked at how a doctor felt when a member of his family took a turn for the worse. The inner struggle that a doctor experiences in this situation was revealed as well as the dangers of being emotionally attached to a patient.

This book related to vertebrate anatomy in more ways than one. For example, an entire chapter was devoted to talking about trying to insert a central line right beneath the clavicle. The term "clavicle" was one that we had just discussed in class through our study of the skeletal system. It also related to anatomy in that the human body and its functions and structural components were repeatedly discussed. As each new surgery was brought up, the author made careful note of how nothing was ever exactly the same in any patient. Just like when we studied frogs, I knew that not everything would be exactly the same, but I had no idea how diverse animals that looked similar on the outside could be on he inside. It's no wonders that doctors sometimes make mistakes. However, through each surgery, Gawande was careful to mention that precautions were taken and that even as the surgery progressed the surgeon kept checking himself to make sure that he was cutting that right thing and not heading straight towards a disaster. For example, during one surgery Gawande and the attending physician were removing a gall bladder and just before they were going to make the cut they stopped, "just as [they] always do and discussed the anatomy" (72) of that particular patient. The book also reassured readers that there was a first time for everything. One should not expect to be perfect on the first try, and even after many trials, perfection may still be far away. As a summarizing statement Gawande noted that "Conscious learning becomes unconscious knowledge" (21). Once again I can relate these thoughts to the frog dissection. As I began to skin the frog, I was very uncertain. Although I might not have cut with correct technique or in the exact right place, I got through it and as I skinned each arm I noticed my self becoming better and better. On the first hand I had about twenty separate pieces of skin by the time that I was done, but by the last one I was able to remove the skin from the entire arm in one piece. Thus, the author gave me confidence and reassured me that everyone has trouble at first.

Not only did the author write this book to reassure people such as myself, he also wrote with the intention of revealing the life a surgeon from a surgeon's vantage point. With the dramatic increase in malpractice law suits, it allowed him to articulate the surgeon's feelings and viewpoints of the situation. In many surgeries that result in malpractice suits, the doctors truly were trying to do the best that they could for their patients. However, because of the gray areas in medicine, choices had to be made and chances had to be taken. Unfortunately, in some cases, the results were not always happy ones. By reading this book the trials and tribulations that a doctor goes through with each patient can be better understood.

Complications also brought to light the fact that being a surgeon is truly a life long learning experience. Graduating from medical school is only the beginning. Every year a surgeon must learn new methods of operating and perfect old ones or else he will inevitably fall behind in a rapidly changing field. At one point the author stated that "what seems most vital and interesting is not how much we in medicine know but how much we don't," (8) implying that the excitement of medicine lays in the discoveries that await it.

The book as a whole, almost like an autobiography of Gawande's life and career thus far as a surgeon, presented information and ideas that had the possibility of coming out bland and boring, as a vibrant and interesting story. It was a successful book in that, not only did it present factual and real life information, it also inspired and sparked interest in the reader to want to find out more about the diversity of medicine and the multi-sided duties that it involves. A good surgeon is not simply one that knows where to make the cut: one also has to be able to deal with patients in a way that makes them feel comfortable and secure.

The one thing that could have been added to the book was how he, as a surgeon, handled failure. Time and time again Gawande discussed his success stories, but, other than a brief side-note, he never truly showed his reactions to a devastating failure such as when his decisions resulted in the death of a patient. If I ever had the opportunity to meet him I would ask him of this. I would also infer about what had made him decide to become a surgeon and about his experiences throughout medical school. Before I had always assumed that most of the surgical training was done there, but I now realize that at the termination of medical school the surgical study has barely even begun. Therefore I wonder what one really goes through as a student. This book was important simply for stirring up these questions. I realize now that the job of a surgeon is far more complicated than I had ever expected, and I have now gained a new respect for surgeons and doctors alike. Never again will I be able to think the same way of doctors and how they perform their duties. I hope that others were equally inspired as well.

Nicole Palmer
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Period 6

The Man Who Mistook His Wife for a Hat Report

The Man Who Mistook His Wife for a Hat is an interesting book comprised of many short stories about those who are neurologically impaired. It details the cases of numerous different people who went to Oliver Sacks for help with their various afflictions and what Sacks did to identify each problem and attempt to solve them individually. Also, The Man Who Mistook His Wife for a Hat gives the reader a glimpse of the life of a person with a life-altering neurological impairment and the lives of their families. It covers many different disorders, from the account of a person suffering from memory loss to a person with the curse and the gift of obtaining the sense of smell of a dog.

There is very little relevance in this book to the vertebrate anatomy and physiology class. Thus far, the course has covered the skeletal and muscular anatomy of the frog and the perch, along with the skeletal system (and soon the muscular system) of the human. The Man Who Mistook His Wife for a Hat goes deeper than the skeletal system and into the brain of the human being. It touches on the human mind and human emotion and what goes on when there is an injury or other problem of the brain. In the case of "Murder," the patient, Donald, while he was under the influence of PCP, unknowingly killed his girlfriend. He did not remember committing the terrible crime until much later when he sustained massive bilateral subdural hematomas in a bicycle accident. The memory of the murder was so intense that he could barely handle it. In the book questions such as "was it possible that the loss of frontal-lobe integrity an essential prerequisite for repression had been lost-and that what we now saw was a sudden, explosive and specific 'de-repression'?" are asked, the sort of questions that most likely will not be brought up while examining the anatomy of a number of different vertebrates (163). It is possible that the book may relate more to the class later on in the year if the brain is fully studied; however, the study very well may not go as in-depth as the book, and will probably not focus on neurological disorders as much as the anatomy of the different parts of locations of these parts in the brain.

This is an enjoyable yet disturbing book. The author's purpose in writing this book was to share the stories of these neurologically disturbed people with the world. He wanted the world to become more familiar with these disorders since many of them are uncommon, and to realize that some of these things can happen to anybody. He wanted the reader to know somewhat what it would be like to be neurologically impaired, and what these people and their loved ones go through on a day to day basis. The author achieved this by explaining in detail each patient's case. With "The Man Who Fell out of Bed," Sacks shows the man's feelings by describing his expression as "a look compounded of stupefaction, incredulity, terror and amusement, not unmixed with a jocular sort of suspicion" (56). One can only imagine how this poor man must have felt when Sacks told him about the “dead” leg being his, and can only feel pity and sorrow towards him when he is asked where his leg is and he believes it has vanished.

The strengths of this book include the ability to pull the reader in through the remarkable and peculiar stories, and the way in which Sacks makes it impossible not to feel for these people. However, every now and then in the book it could be hard to follow along with the exact neurological problem if the reader is not familiar with the terminology and the different disorders. For example, in “The Dog Beneath the Skin” it was such an interesting and bizarre concept that it was hard to put the book down, whereas in the postscript of “Phantoms” he states that “Dr. Cole has also presented detailed electrophysiological studies of a patient with a sensory polyneuropathy of fourteen years’ duration” and totally loses the reader with large and unfamiliar terms (70).

This book teaches about the wide range of things that can go wrong in any person’s brain. It shows how a neurologically impaired person feels and what it is like to have a friend or family member with some sort of disorder. It is important to know that a person with a neurological disorder is still a person, even if he cannot remember his past or hears music playing even when his surroundings are silent. These things can happen at any time and at any place, which is demonstrated by “The Disembodied Lady” who lost her proprioception before having routine surgery at the age of twenty-seven, and Mrs. O’M, who began hearing music and voices one day when she was in her eighties “while she was grating parsnips in the kitchen” (135).

After reading this book, one cannot help but have a few questions for the author, Oliver Sacks. What made him decide to pursue this career? Was there a specific incident that made him decide to study neurology? Has he ever encountered a patient whom he just did not know how to handle? What did he do if this happened? Has he ever falsely suspected himself of having a certain neurological disorder, but then realized that he was just being paranoid? If he has, then has that happened often? So often that he sometimes wishes he went into a different field of study? What other field of study would he be interested in? A person who is fascinated by the stories in this book and plans to go on to deal with the neurologically impaired could not help but wonder if knowing so much about their own brain would change the way they act and live. Finally, one might wonder why he decided to write a book about all of these different patients, and why he chose to write about the specific patients that he wrote about.

Viruses of the Mind
Richard Dawkins

1991

> The haven all memes depend on reaching is the human mind, but a human mind is itself an artifact created when memes restructure a human brain in order to make it a better habitat for memes. The avenues for entry and departure are modified to suit local conditions, and strengthened by various artificial devices that enhance fidelity and prolixity of replication: native Chinese minds differ dramatically from native French minds, and literate minds differ from illiterate minds. What memes provide in return to the organisms in which they reside is an incalculable store of advantages --- with some Trojan horses thrown in for good measure. . .
>
> Daniel Dennett, *Consciousness Explained*

1 Duplication Fodder

A beautiful child close to me, six and the apple of her father's eye, believes that Thomas the Tank Engine really exists. She believes in Father Christmas, and when she grows up her ambition is to be a tooth fairy. She and her school-friends believe the solemn word of respected adults that tooth fairies and Father Christmas really exist. This little girl is of an age to believe whatever you tell her. If you tell her about witches changing princes into frogs she will believe you. If you tell her that bad children roast forever in hell she will have nightmares. I have just discovered that without her father's consent this sweet, trusting, gullible six-year-old is being sent, for weekly instruction, to a Roman Catholic nun. What chance has she?

A human child is shaped by evolution to soak up the culture of her people. Most obviously, she learns the essentials of their language in a matter of months. A large dictionary of words to speak, an encyclopedia of information to speak about, complicated syntactic and semantic rules to order the speaking, are all transferred from older brains into hers well before she reaches half her adult size. When you are pre-programmed to absorb useful information at a high rate, it is hard to shut out pernicious or damaging information at the same time. With so many mindbytes to be downloaded, so many mental codons to be replicated, it is no wonder that child brains are gullible, open to almost any suggestion, vulnerable to subversion, easy prey to Moonies, Scientologists and nuns. Like immune-deficient patients, children are wide open to mental infections that adults might brush off without effort.

DNA, too, includes parasitic code. Cellular machinery is extremely good at copying DNA. Where DNA is concerned, it seems to have an eagerness to copy, seems eager to be copied. The cell nucleus is a paradise for DNA, humming with sophisticated, fast, and accurate duplicating machinery.

Cellular machinery is so friendly towards DNA duplication that it is small wonder cells play host to DNA parasites --- viruses, viroids, plasmids and a riff-raff of other genetic fellow travelers. Parasitic DNA even gets itself spliced seamlessly into the chromosomes themselves. ``Jumping genes'' and stretches of ``selfish DNA'' cut or copy themselves out of chromosomes and paste themselves in elsewhere. Deadly oncogenes are almost impossible to distinguish from the legitimate genes between which they are spliced. In evolutionary time, there is probably a continual traffic from ``straight'' genes to ``outlaw,'' and back again (Dawkins, 1982). DNA is just DNA. The only thing that distinguishes viral DNA from host DNA is its expected method of passing into future generations. ``Legitimate'' host DNA is just DNA that aspires to pass into the next generation via the orthodox route of sperm or egg. ``Outlaw'' or parasitic DNA is just DNA that looks to a quicker, less cooperative route to the future, via a squeezed droplet or a smear of blood, rather than via a sperm or egg.

For data on a floppy disc, a computer is a humming paradise just as cell nuclei hum with eagerness to duplicate DNA. Computers and their associated disc and tape readers are designed with high fidelity in mind. As with DNA molecules, magnetized bytes don't literally ``want'' to be faithfully copied. Nevertheless, you can write a computer program that takes steps to duplicate itself. Not just duplicate itself within one computer but spread itself to other computers. Computers are so good at copying bytes, and so good at faithfully obeying the instructions contained in those bytes, that they are sitting ducks to self-replicating programs: wide open to subversion by software parasites. Any cynic familiar with the theory of selfish genes and memes would have known that modern personal computers, with their promiscuous traffic of floppy discs and e-mail links, were just asking for trouble. The only surprising thing about the current epidemic of computer viruses is that it has been so long in coming.

2 Computer Viruses: a Model for an Informational Epidemiology

Computer viruses are pieces of code that graft themselves into existing, legitimate programs and subvert the normal actions of those programs. They may travel on exchanged floppy disks, or over networks. They are technically distinguished from ``worms'' which are whole programs in their own right, usually traveling over networks. Rather different are ``Trojan horses,'' a third category of destructive programs, which are not in themselves self-replicating but rely on humans to replicate them because of their pornographic or otherwise appealing content. Both viruses and worms are programs that actually say, in computer language, ``Duplicate me.'' Both may do other things that make their presence felt and perhaps satisfy the hole-in-corner vanity of their authors. These side-effects may be ``humorous'' (like the virus that makes the Macintosh's built-in loudspeaker enunciate the words ``Don't panic,'' with predictably opposite effect); malicious (like the numerous IBM viruses that erase the hard disk after a sniggering screen-announcement of the impending disaster); political (like the Spanish Telecom and Beijing viruses that protest about telephone costs and massacred students respectively); or simply inadvertent (the programmer is incompetent to handle the low-level system calls required to write an effective virus or worm). The famous Internet Worm, which paralyzed much of the computing power of the United States on November 2, 1988, was not intended (very) maliciously but got out of control and, within 24 hours, had clogged around 6,000 computer memories with exponentially multiplying copies of itself.

``Memes now spread around the world at the speed of light, and replicate at rates that make even fruit flies and yeast cells look glacial in comparison. They leap promiscuously from vehicle to vehicle, and from medium to medium, and are proving to be virtually unquarantinable'' (Dennett 1990, p.131). Viruses aren't limited to electronic media such as disks and data lines. On its way from one computer to another, a virus may pass through printing ink, light rays in a human lens, optic nerve impulses and finger muscle contractions. A computer fanciers' magazine that printed the text of a virus program for the interest of its readers has been widely condemned. Indeed, such is the appeal of the virus idea to a certain kind of puerile mentality (the masculine gender is used advisedly), that publication of any kind of ``how to'' information on designing virus programs is rightly seen as an irresponsible act.

I am not going to publish any virus code. But there are certain tricks of effective virus design that are sufficiently well known, even obvious, that it will do no harm to mention them, as I need to do to develop my theme. They all stem from the virus's need to evade detection while it is spreading.

A virus that clones itself too prolifically within one computer will soon be detected because the symptoms of clogging will become too obvious to ignore. For this reason many virus programs check, before infecting a system, to make sure that they are not already on that system. Incidentally, this opens the way for a defense against viruses that is analogous to immunization. In the days before a specific anti-virus program was available, I myself responded to an early infection of my own hard disk by means of a crude ``vaccination.'' Instead of deleting the virus that I had detected, I simply disabled its coded instructions, leaving the ``shell'' of the virus with its characteristic external ``signature'' intact. In theory, subsequent members of the same virus species that arrived in my system should have recognized the signature of their own kind and refrained from trying to double-infect. I don't know whether this immunization really worked, but in those days it probably was worth while ``gutting'' a virus and leaving a shell like this, rather than simply removing it lock, stock and barrel. Nowadays it is better to hand the problem over to one of the professionally written anti-virus programs.

A virus that is too virulent will be rapidly detected and scotched. A virus that instantly and catastrophically sabotages every computer in which it finds itself will not find itself in many computers. It may have a most amusing effect on one computer ---- erase an entire doctoral thesis or something equally side-splitting --- but it won't spread as an epidemic.

Some viruses, therefore, are designed to have an effect that is small enough to be difficult to detect, but which may nevertheless be extremely damaging. There is one type, which, instead of erasing disk sectors wholesale, attacks only spreadsheets, making a few random changes in the (usually financial) quantities entered in the rows and columns. Other viruses evade detection by being triggered probabilistically, for example erasing only one in 16 of the hard disks infected. Yet other viruses employ the time-bomb principle. Most modern computers are ``aware'' of the date, and viruses have been triggered to manifest themselves all around the world, on a particular date such as Friday 13th or April Fool's Day. From the parasitic point of view, it doesn't matter how catastrophic the eventual attack is, provided the virus has had plenty of opportunity to spread first (a disturbing analogy to the Medawar/Williams theory of ageing: we are the victims of lethal and sub-lethal genes that mature only after we have had plenty of time to reproduce (Williams, 1957)). In defense, some large companies go so far as to set aside one ``miner's canary'' among their fleet of computers, and advance its internal calendar a week so that any time-bomb viruses will reveal themselves prematurely before the big day.

Again predictably, the epidemic of computer viruses has triggered an arms race. Anti-viral software is doing a roaring trade. These antidote programs -- ``Interferon,'' ``Vaccine,'' ``Gatekeeper'' and others --- employ a diverse armory of tricks. Some are written with specific, known and named viruses in mind. Others intercept any attempt to meddle with sensitive system areas of memory and warn the user.

The virus principle could, in theory, be used for non-malicious, even beneficial purposes. Thimbleby (1991) coins the phrase ``liveware'' for his already-implemented use of the infection principle for keeping multiple copies of databases up to date. Every time a disk containing the database is plugged into a computer, it looks to see whether there is already another copy present on the local hard disk. If there is, each copy is updated in the light of the other. So, with a bit of luck, it doesn't matter which member of a circle of colleagues enters, say, a new bibliographical citation on his personal disk. His newly entered information will readily infect the disks of his colleagues (because the colleagues promiscuously insert their disks into one another's computers) and will spread like an epidemic around the circle. Thimbleby's liveware is not entirely virus-like: it could not spread to just anybody's computer and do damage. It spreads data only to already-existing copies of its own database; and you will not be infected by liveware unless you positively opt for infection.

Incidentally, Thimbleby, who is much concerned with the virus menace, points out that you can gain some protection by using computer systems that other people don't use. The usual justification for purchasing today's numerically dominant computer is simply and solely that it *is* numerically dominant. Almost every knowledgeable person agrees that, in terms of quality and especially user-friendliness, the rival, minority system is superior. Nevertheless, ubiquity is held to be good in itself, sufficient to outweigh sheer quality. Buy the same (albeit inferior) computer as your colleagues, the argument goes, and you'll be able to benefit from shared software, and from a generally large circulation of available software. The irony is that, with the advent of the virus plague, ``benefit'' is not all that you are likely to get. Not only should we all be very hesitant before we accept a disk from a colleague. We should also be aware that, if we join a large community of users of a particular make of computer, we are also joining a large community of viruses --- even, it turns out, *disproportionately* larger.

Returning to possible uses of viruses for positive purposes, there are proposals to exploit the ``poacher turned gamekeeper'' principle, and ``set a thief to catch a thief.'' A simple way would be to take any of the existing anti-viral programs and load it, as a ``warhead,'' into a harmless self-replicating virus. From a ``public health'' point of view, a spreading epidemic of anti-viral software could be especially beneficial because the computers most vulnerable to malicious viruses --- those whose owners are promiscuous in the exchange of pirated programs --- will also be most vulnerable to infection by the healing anti-virus. A more penetrating anti-virus might --- as in the immune system --- ``learn'' or ``evolve'' an improved capacity to attack whatever viruses it encountered.

I can imagine other uses of the computer virus principle which, if not exactly altruistic, are at least constructive enough to escape the charge of pure vandalism. A computer company might wish to do market research on the habits of its customers, with a view to improving the design of future products. Do users like to choose files by pictorial icon, or do they opt to display them by textual name only? How deeply do people nest folders (directories) within one another? Do people settle down for a long session with only one program, say a word processors, or are they constantly switching back and forth, say between writing and drawing programs? Do people succeed in moving the mouse pointer straight to the target, or do they meander around in time-wasting hunting movements that could be rectified by a change in design?

The company could send out a questionnaire asking all these questions, but the customers that replied would be a biased sample and, in any case, their own assessment of their computer-using behavior might be inaccurate. A better solution would be a market-research computer program. Customers would be asked to load this program into their system where it would unobtrusively sit, quietly monitoring and tallying key-presses and mouse movements. At the end of a year, the customer would be asked to send in the disk file containing all the tallyings of the market-research program. But again, most people would not bother to cooperate and some might see it as an invasion of privacy and of their disk space.

The perfect solution, from the company's point of view, would be a virus. Like any other virus, it would be self-replicating and secretive. But it would not be destructive or facetious like an ordinary virus. Along with its self-replicating booster it would contain a market-research warhead. The virus would be released surreptitiously into the community of computer users. Just like an ordinary virus it would spread around, as people passed floppy disks and e-mail around the community. As the virus spread from computer to computer, it would build up statistics on users behavior, monitored secretly from deep within a succession of systems. Every now and again, a copy of the viruses would happen to find its way, by normal epidemic traffic, back into one of the company's own computers. There it would be debriefed and its data collated with data from other copies of the virus that had come ``home.''

Looking into the future, it is not fanciful to imagine a time when viruses, both bad and good, have become so ubiquitous that we could speak of an ecological community of viruses and legitimate programs coexisting in the silicosphere. At present, software is advertised as, say, ``Compatible with System 7.'' In the future, products may be advertised as ``Compatible with all viruses registered in the 1998 World Virus Census; immune to all listed virulent viruses; takes full advantage of the facilities offered by the following benign viruses if present...'' Word-processing software, say, may hand over particular functions, such as word-counting and string-searches, to friendly viruses burrowing autonomously through the text.

Looking even further into the future, whole integrated software systems might grow, not by design, but by something like the growth of an ecological community such as a tropical rain-forest. Gangs of mutually compatible viruses might grow up, in the same way as genomes can be regarded as gangs of mutually compatible genes (Dawkins, 1982). Indeed, I have even suggested that our genomes should be regarded as gigantic colonies of viruses (Dawkins, 1976). Genes cooperate with one another in genomes because natural selection has favored those genes that prosper in the presence of the other genes that happen to be common in the gene pool. Different gene pools may evolve towards different combinations of mutually compatible genes. I envisage a time when, in the same kind of way, computer viruses may evolve towards compatibility with other viruses, to form communities or gangs. But then again, perhaps not! At any rate, I find the speculation more alarming than exciting.

At present, computer viruses don't strictly evolve. They are invented by human programmers, and if they evolve they do so in the same weak sense as cars or aeroplanes evolve. Designers derive this year's car as a slight modification of last year's car, and then may, more or less consciously, continue a trend of the last few years --- further flattening of the radiator grill or whatever it may be. Computer virus designers dream up ever more devious tricks for outwitting the programmers of anti-virus software. But computer viruses don't --- so far --- mutate and evolve by true natural selection. They may do so in the future. Whether they evolve by natural selection, or whether their evolution is steered by human designers, may not make much difference to their eventual performance. By either kind of evolution, we expect them to become better at concealment, and we expect them to become subtly compatible with other viruses that are at the same time prospering in the computer community.

DNA viruses and computer viruses spread for the same reason: an environment exists in which there is machinery well set up to duplicate and spread them around and to obey the instructions that the viruses embody. These two environments are, respectively, the environment of cellular physiology and the environment provided by a large community of computers and data-handling machinery. Are there any other environments like these, any other humming paradises of replication?

3 The Infected Mind

I have already alluded to the programmed-in gullibility of a child, so useful for learning language and traditional wisdom, and so easily subverted by nuns, Moonies and their ilk. More generally, we all exchange information with one another. We don't exactly plug floppy disks into slots in one another's skulls, but we exchange sentences, both through our ears and through our eyes. We notice each other's styles of moving and dressing and are influenced. We take in advertising jingles, and are presumably persuaded by them, otherwise hard-headed businessmen would not spend so much money polluting their air with them.

Think about the two qualities that a virus, or any sort of parasitic replicator, demands of a friendly medium,. the two qualities that make cellular machinery so friendly towards parasitic DNA, and that make computers so friendly towards computer viruses. These qualities are, firstly, a readiness to replicate information accurately, perhaps with some mistakes that are subsequently reproduced accurately; and, secondly, a readiness to obey instructions encoded in the information so replicated.

Cellular machinery and electronic computers excel in both these virus-friendly qualities. How do human brains match up? As faithful duplicators, they are certainly less perfect than either cells or electronic computers. Nevertheless, they are still pretty good, perhaps about as faithful as an RNA virus, though not as good as DNA with all its elaborate proofreading measures against textual degradation. Evidence of the fidelity of brains, especially child brains, as data duplicators is provided by language itself. Shaw's Professor Higgins was able by ear alone to place Londoners in the street where they grew up. Fiction is not evidence for anything, but everyone knows that Higgins's fictional skill is only an exaggeration of something we can all down. Any American can tell Deep South from Mid West, New England from Hillbilly. Any New Yorker can tell Bronx from Brooklyn. Equivalent claims could be substantiated for any country. What this phenomenon means is that human brains are capable of pretty accurate copying (otherwise the accents of, say, Newcastle would not be stable enough to be recognized) but with some mistakes (otherwise pronunciation would not evolve, and all speakers of a language would inherit identically the same accents from their remote ancestors). Language evolves, because it has both the great stability and the slight changeability that are prerequisites for any evolving system.

The second requirement of a virus-friendly environment --- that it should obey a program of coded instructions --- is again only quantitatively less true for brains than for cells or computers. We sometimes obey orders from one another, but also we sometimes don't. Nevertheless, it is a telling fact that, the world over, the vast majority of children follow the religion of their parents rather than any of the other available religions. Instructions to genuflect, to bow towards Mecca, to nod one's head rhythmically towards the wall, to shake like a maniac, to ``speak in tongues'' --- the list of such arbitrary and pointless motor patterns offered by religion alone is extensive --- are obeyed, if not slavishly, at least with some reasonably high statistical probability.

Less portentously, and again especially prominent in children, the ``craze'' is a striking example of behavior that owes more to epidemiology than to rational choice. Yo-yos, hula hoops and pogo sticks, with their associated behavioral fixed actions, sweep through schools, and more sporadically leap from school to school, in patterns that differ from a measles epidemic in no serious particular. Ten years ago, you could have traveled thousands of miles through the United States and never seen a baseball cap turned back to front. Today, the reverse baseball cap is ubiquitous. I do not know what the pattern of geographical spread of the reverse baseball cap precisely was, but epidemiology is certainly among the professions primarily qualified to study it. We don't have to get into arguments about ``determinism''; we don't have to claim that children are compelled to imitate their fellows' hat fashions. It is enough that their hat-wearing behavior, as a matter of fact, *is* statistically affected by the hat-wearing behavior of their fellows.

Trivial though they are, crazes provide us with yet more circumstantial evidence that human minds, especially perhaps juvenile ones, have the qualities that we have singled out as desirable for an informational parasite. At the very least the mind is a plausible *candidate* for infection by something like a computer virus, even if it is not quite such a parasite's dream-environment as a cell nucleus or an electronic computer.

It is intriguing to wonder what it might feel like, from the inside, if one's mind were the victim of a ``virus.'' This might be a deliberately designed parasite, like a present-day computer virus. Or it might be an inadvertently mutated and unconsciously evolved parasite. Either way, especially if the evolved parasite was the memic descendant of a long line of successful ancestors, we are entitled to expect the typical ``mind virus'' to be pretty good at its job of getting itself successfully replicated.

Progressive evolution of more effective mind-parasites will have two aspects. New ``mutants'' (either random or designed by humans) that are better at spreading will become more numerous. And there will be a ganging up of ideas that flourish in one another's presence, ideas that mutually support one another just as genes do and as I have speculated computer viruses may one day do. We expect that replicators will go around together from brain to brain in mutually compatible gangs. These gangs will come to constitute a package, which may be sufficiently stable to deserve a collective name such as Roman Catholicism or Voodoo. It doesn't too much matter whether we analogize the whole package to a single virus, to each one of the component parts to a single virus. The analogy is not that precise anyway, just as the distinction between a computer virus and a computer worm is nothing to get worked up about. What matters is that minds are friendly environments to parasitic, self-replicating ideas or information, and that minds are typically massively infected.

Like computer viruses, successful mind viruses will tend to be hard for their victims to detect. If you are the victim of one, the chances are that you won't know it, and may even vigorously deny it. Accepting that a virus might be difficult to detect in your own mind, what tell-tale signs might you look out for? I shall answer by imaging how a medical textbook might describe the typical symptoms of a sufferer (arbitrarily assumed to be male).

1. The patient typically finds himself impelled by some deep, inner conviction that something is true, or right, or virtuous: a conviction that doesn't seem to owe anything to evidence or reason, but which, nevertheless, he feels as totally compelling and convincing. We doctors refer to such a belief as ``faith.''

2. Patients typically make a positive virtue of faith's being strong and unshakable, *in spite of* not being based upon evidence. Indeed, they may fell that the less evidence there is, the more virtuous the belief (see below).

This paradoxical idea that lack of evidence is a positive virtue where faith is concerned has something of the quality of a program that is self-sustaining, because it is self-referential (see the chapter ``On Viral Sentences and Self-Replicating Structures'' in Hofstadter, 1985). Once the proposition is believed, it automatically undermines opposition to itself. The ``lack of evidence is a virtue'' idea could be an admirable sidekick, ganging up with faith itself in a clique of mutually supportive viral programs.

3. A related symptom, which a faith-sufferer may also present, is the conviction that ``mystery,'' *per se,* is a good thing. It is not a virtue to solve mysteries. Rather we should enjoy them, even revel in their insolubility.

Any impulse to solve mysteries could be serious inimical to the spread of a mind virus. It would not, therefore, be surprising if the idea that ``mysteries are better not solved'' was a favored member of a mutually supporting gang of viruses. Take the ``Mystery of Transubstantiation.'' It is easy and non-mysterious to believe that in some symbolic or metaphorical sense the eucharistic wine turns into the blood of Christ. The Roman Catholic doctrine of transubstantiation, however, claims far more. The ``whole substance'' of the wine is converted into the blood of Christ; the appearance of wine that remains is ``merely accidental,'' ``inhering in no substance'' (Kenny, 1986, p. 72). Transubstantiation is colloquially taught as meaning that the wine ``literally'' turns into the blood of Christ. Whether in its obfuscatory Aristotelian or its franker colloquial form, the claim of transubstantiation can be made only if we do serious violence to the normal meanings of words like ``substance'' and ``literally.'' Redefining words is not a sin, but, if we use words like ``whole substance'' and ``literally'' for this case, what word are we going to use when we really and truly *want* to say that something did actually happen? As Anthony Kenny observed of his own puzzlement as a young seminarian, ``For all I could tell, my typewriter might be Benjamin Disraeli transubstantiated....''

Roman Catholics, whose belief in infallible authority compels them to accept that wine becomes physically transformed into blood despite all appearances, refer to the ``mystery'' of transubstantiation. Calling it a mystery makes everything OK, you see. At least, it works for a mind well prepared by background infection. Exactly the same trick is performed in the ``mystery'' of the Trinity. Mysteries are not meant to be solved, they are meant to strike awe. The ``mystery is a virtue'' idea comes to the aid of the Catholic, who would otherwise find intolerable the obligation to believe the obvious nonsense of the transubstantiation and the ``three-in-one.'' Again, the belief that ``mystery is a virtue'' has a self-referential ring. As Hofstadter might put it, the very mysteriousness of the belief moves the believer to perpetuate the mystery.

An extreme symptom of ``mystery is a virtue'' infection is Tertullian's ``*Certum est quia impossibile est*'' (It is certain because it is impossible''). That way madness lies. One is tempted to quote Lewis Carroll's White Queen, who, in response to Alice's ``One can't believe impossible things'' retorted ``I daresay you haven't had much practice... When I was your age, I always did it for half-an-hour a day. Why, sometimes I've believed as many as six impossible things before breakfast.'' Or Douglas Adam's Electric Monk, a labor-saving device programmed to do your believing for you, which was capable of ``believing things they'd have difficulty believing in Salt Lake City'' and which, at the moment of being introduced to the reader, believed, contrary to all the evidence, that everything in the world was a uniform shade of pink. But White Queens and Electric Monks become less funny when you realize that these virtuoso believers are indistinguishable from revered theologians in real life. ``It is by all means to be believed, because it is absurd'' (Tertullian again). Sir Thomas Browne (1635) quotes Tertullian with approval, and goes further: ``Methinks there be not impossibilities enough in religion for an active faith.'' And ``I desire to exercise my faith in the difficultest point; for to credit ordinary and visible objects is not faith, but perswasion [sic].''

I have the feeling that something more interesting is going on here than just plain insanity or surrealist nonsense, something akin to the admiration we feel when we watch a ten-ball juggler on a tightrope. It is as though the faithful gain prestige through managing to believe even more impossible things than their rivals succeed in believing. Are these people testing

--- exercising --- their believing muscles, training themselves to believe impossible things so that they can take in their stride the merely improbable things that they are ordinarily called upon to believe?

While I was writing this, the *Guardian* (July 29, 1991) fortuitously carried a beautiful example. It came in an interview with a rabbi undertaking the bizarre task of vetting the kosher-purity of food products right back to the ultimate origins of their minutest ingredients. He was currently agonizing over whether to go all the way to China to scrutinize the menthol that goes into cough sweets. ``Have you ever tried checking Chinese menthol... it was extremely difficult, especially since the first letter we sent received the reply in best Chinese English, `The product contains no kosher'... China has only recently started opening up to kosher investigators. The menthol should be OK, but you can never be absolutely sure unless you visit." These kosher investigators run a telephone hot-line on which up-to-the-minute red-alerts of suspicion are recorded against chocolate bars and cod-liver oil. The rabbi sighs that the green-inspired trend away from artificial colors and flavors ``makes life miserable in the kosher field because you have to follow all these things back." When the interviewer asks him why he bothers with this obviously pointless exercise, he makes it very clear that the point is precisely that there *is* no point:

> That most of the Kashrut laws are divine ordinances without reason given is 100 per cent the point. It is very easy not to murder people. Very easy. It is a little bit harder not to steal because one is tempted occasionally. So that is no great proof that I believe in God or am fulfilling His will. But, if He tells me not to have a cup of coffee with milk in it with my mincemeat and peaces at lunchtime, that is a test. The only reason I am doing that is because I have been told to so do. It is something difficult.

Helena Cronin has suggested to me that there may be an analogy here to Zahavi's handicap theory of sexual selection and the evolution of signals (Zahavi, 1975). Long unfashionable, even ridiculed (Dawkins, 1976), Zahavi's theory has recently been cleverly rehabilitated (Grafen, 1990 a, b) and is now taken seriously by evolutionary biologists (Dawkins, 1989). Zahavi suggests that peacocks, for instance, evolve their absurdly burdensome fans with their ridiculously conspicuous (to predators) colors, precisely *because* they are burdensome and dangerous, and therefore impressive to females. The peacock is, in effect, saying: ``Look how fit and strong I must be, since I can afford to carry around this preposterous tail."

To avoid misunderstanding of the subjective language in which Zahavi likes to make his points, I should add that the biologist's convention of personifying the unconscious actions of natural selection is taken for granted here. Grafen has translated the argument into an orthodox Darwinian mathematical model, and it works. No claim is here being made about the intentionality or awareness of peacocks and peahens. They can be as sphexish or as intentional as you please (Dennett, 1983, 1984). Moreover, Zahavi's theory is general enough not to depend upon a Darwinian underpinning. A flower advertising its nectar to a ``skeptical" bee could benefit from the Zahavi principle. But so could a human salesman seeking to impress a client.

The premise of Zahavi's idea is that natural selection will favor skepticism among females (or among recipients of advertising messages generally). The only way for a male (or any advertiser) to authenticate his boast of strength (quality, or whatever is is) is to prove that it is true by shouldering a truly costly handicap --- a handicap *that only a genuinely strong* (high quality, etc.) male could bear. It may be called the principle of costly authentication. And now to the point. Is it possible that some religious doctrines are favored not *in spite of* being ridiculous but precisely *because* they are ridiculous? Any wimp in religion could believe that bread *symbolically* represents the body of Christ, but it takes a real, red-blooded Catholic to believe something as daft as the transubstantiation. If you believe that you can believe anything, and (witness the story of Doubting Thomas) these people are trained to see that as a virtue.

Let us return to our list of symptoms that someone afflicted with the mental virus of faith, and its accompanying gang of secondary infections, may expect to experience.

4. The sufferer may find himself behaving intolerantly towards vectors of rival faiths, in extreme cases even killing them or advocating their deaths. He may be similarly violent in his disposition towards apostates (people who once held the faith but have renounced it); or towards heretics (people who espouse a different --- often, perhaps significantly, only very slightly different --- version of the faith). He may also feel hostile towards other modes of thought that are potentially inimical to his faith, such as the method of scientific reason which may function rather like a piece of anti-viral software.

The threat to kill the distinguished novelist Salman Rushdie is only the latest in a long line of sad examples. On the very day that I wrote this, the Japanese translator of *The Satanic Verses* was found murdered, a week after a near-fatal attack on the Italian translator of the same book. By the way, the apparently opposite symptom of ``sympathy'' for Muslim ``hurt,'' voiced by the Archbishop of Canterbury and other Christian leaders (verging, in the case of the Vatican, on outright criminal complicity) is, of course, a manifestation of the symptom we discussed earlier: the delusion that faith, however obnoxious its results, has to be respected simply because it *is* faith.

Murder is an extreme, of course. But there is an even more extreme symptom, and that is suicide in the militant service of a faith. Like a soldier ant programmed to sacrifice her life for germ-line copies of the genes that did the programming, a young Arab or Japanese [??!] is taught that to die in a holy war is the quickest way to heaven. Whether the leaders who exploit him really believe this does not diminish the brutal power that the ``suicide mission virus'' wields on behalf of the faith. Of course suicide, like murder, is a mixed blessing: would-be converts may be repelled, or may treat with contempt a faith that is perceived as insecure enough to need such tactics.

More obviously, if too many individuals sacrifice themselves the supply of believers could run low. This was true of a notorious example of faith-inspired suicide, though in this case it was not ``kamikaze'' death in battle. The Peoples' Temple sect became extinct when its leader, the Reverend Jim Jones, led the bulk of his followers from the United States to the Promised Land of ``Jonestown'' in the Guyanan jungle where he persuaded more than 900 of them, children first, to drink cyanide. The macabre affair was fully investigated by a team from the *San Francisco Chronicle* (Kilduff and Javers, 1978).

> Jones, ``the Father," had called his flock together and told them it was time to depart for heaven.
> ``We're going to meet," he promised, ``in another place."
> The words kept coming over the camp's loudspeakers.
> ``There is great dignity in dying. It is a great demonstration for everyone to die."

Incidentally, it does not escape the trained mind of the alert sociobiologist that Jones, within his sect in earlier days, ``proclaimed himself the only person permitted to have sex" (presumably his partners were also permitted). ``A secretary would arrange for Jones's liaisons. She would call up and say, `Father hates to do this, but he has this tremendous urge and could you please...?' " His victims were not only female. One 17-year-old male follower, from the days when Jones's community was still in San Francisco, told how he was taken for dirty weekends to a hotel where Jones received a ``minister's discount for Rev. Jim Jones and son." The same boy said: ``I was really in awe of him. He was more than a father. I would have killed my parents for him." What is remarkable about the Reverend Jim Jones is not his own self-serving behavior but the almost superhuman gullibility of his followers. Given such prodigious credulity, can anyone doubt that human minds are ripe for malignant infection?

Admittedly, the Reverend Jones conned only a few thousand people. But his case is an extreme, the tip of an iceberg. The same eagerness to be conned by religious leaders is widespread. Most of us would have been prepared to bet that nobody could get away with going on television and saying, in all but so many words, ``Send me your money, so that I can use it to persuade other suckers to send me their money too." Yet today, in every major conurbation in the United States, you can find at least one television evangelist channel entirely devoted to this transparent confidence trick. And they get away with it in sackfuls. Faced with suckerdom on this awesome scale, it is hard not to feel a grudging sympathy with the shiny-suited conmen. Until you realize that not all the suckers are rich, and that it is often widows' mites on which the evangelists are growing fat. I have even heard one of them explicitly invoking the principle that I now identify with Zahavi's principle of costly authentication. God really appreciates a donation, he said with passionate sincerity, only when that donation is so large that it hurts. Elderly paupers were wheeled on to testify how much happier they felt since they had made over their little all to the Reverend whoever it was.

5. The patient may notice that the particular convictions that he holds, while having nothing to do with evidence, do seem to owe a great deal to epidemiology. Why, he may wonder, do I hold *this* set of convictions rather than *that* set? Is it because I surveyed all the world's faiths and chose the one whose claims seemed most convincing? Almost certainly not. If you have a faith, it is statistically overwhelmingly likely that it is the same faith as your parents and grandparents had. No doubt soaring cathedrals, stirring music, moving stories and parables, help a bit. But by far the most important variable determining your religion is the accident of birth. The convictions that you so passionately believe would have been a completely different, and largely contradictory, set of convictions, if only you had happened to be born in a different place. Epidemiology, not evidence.

6. If the patient is one of the rare exceptions who follows a different religion from his parents, the explanation may still be epidemiological. To be sure, it is *possible* that he dispassionately surveyed the world's faiths and chose the most convincing one. But it is statistically more probable that he has been exposed to a particularly potent infective agent --- a John Wesley, a Jim Jones or a St. Paul. Here we are talking about horizontal transmission, as in measles. Before, the epidemiology was that of vertical transmission, as in Huntington's Chorea.

7. The internal sensations of the patient may be startlingly reminiscent of those more ordinarily associated with sexual love. This is an extremely potent force in the brain, and it is not surprising that some viruses have evolved to exploit it. St. Teresa of Avila's famously orgasmic vision is too notorious to need quoting again. More seriously, and on a less crudely sensual plane, the philosophy Anthony Kenny provides moving testimony to the pure delight that awaits those that manage to believe in the mystery of transubstantiation. After describing his ordination as a Roman Catholic priest, empowered by laying on of hands to celebrate Mass, he goes on that he vividly recalls

> the exaltation of the first months during which I had the power to say Mass. Normally a slow and sluggish riser, I would leap early out of bed, fully awake and full of excitement at the thought of the momentous act I was privileged to perform. I rarely said the public Community Mass: most days I celebrated alone at a side altar with a junior member of the College to serve as acolyte and congregation. But that made no difference to the solemnity of the sacrifice or the validity of the consecration.
> It was touching the body of Christ, the closeness of the priest to Jesus, which most enthralled me. I would gaze on the Host after the words of consecration, soft-eyed like a lover looking into the eyes of his beloved... Those early days as a priest remain in my memory as days of fulfilment and tremulous happiness; something precious, and yet too fragile to last, like a romantic love-affair brought up short by the reality of an ill-assorted marriage. (Kenny, 1986, pp. 101-2)

Dr. Kenny is affectingly believable that it felt to him, as a young priest, as though he was in love with the consecrated host. What a brilliantly successful virus! On the same page, incidentally, Kenny also shows us that the virus is transmitted contagiously --- if not literally then at least in some sense --- from the palm of the infecting bishop's hand through the top of the new priest's head:

> If Catholic doctrine is true, every priest validly ordained derives his orders in an unbroken line of laying on of hands, through the bishop who ordains him, back to one of the twelve Apostles... there must be centuries-long, recorded chains of layings on of hands. It surprises me that priests never seem to trouble to trace their spiritual ancestry in this way, finding out who ordained their bishop, and who ordained him, and so on to Julius II or Celestine V or Hildebrand, or Gregory the Great, perhaps. (Kenny, 1986, p. 101)

It surprises me, too.

4 Is Science a Virus

No. Not unless all computer programs are viruses. Good, useful programs spread because people evaluate them, recommend them and pass them on. Computer viruses spread solely because they embody the coded instructions: ``Spread me.'' Scientific ideas, like all memes, are subject to a kind of natural selection, and this might look superficially virus-like. But the selective forces that scrutinize scientific ideas are not arbitrary and capricious. They are exacting, well-honed rules, and they do not favor pointless self-serving behavior. They favor all the virtues laid out in textbooks of standard methodology: testability, evidential support, precision, quantifiability, consistency, intersubjectivity, repeatability, universality, progressiveness, independence of cultural milieu, and so on. Faith spreads despite a total lack of every single one of these virtues.

You may find elements of epidemiology in the spread of scientific ideas, but it will be largely descriptive epidemiology. The rapid spread of a good idea through the scientific community may even look like a description of a measles epidemic. But when you examine the underlying reasons you find that they are good ones, satisfying the demanding standards of scientific method. In the history of the spread of faith you will find little else but epidemiology, and causal epidemiology at that. The reason why person A believes one thing and B believes another is simply and solely that A was born on one continent and B on another. Testability, evidential support and the rest aren't even remotely considered. For scientific belief, epidemiology merely comes along afterwards and describes the history of its acceptance. For religious belief, epidemiology is the root cause.

5 Epilogue

Happily, viruses don't win every time. Many children emerge unscathed from the worst that nuns and mullahs can throw at them. Anthony Kenny's own story has a happy ending. He eventually renounced his orders because he could no longer tolerate the obvious contradictions within Catholic belief, and he is now a highly respected scholar. But one cannot help remarking that it must be a powerful infection indeed that took a man of his wisdom and intelligence --- President of the British Academy, no less --- three decades to fight off. Am I unduly alarmist to fear for the soul of my six-year-old innocent?

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Richard Dimbleby Lecture on Science, Delusion & the Appetite for Wonder
Richard Dimbleby Lecture, BBC1 Television, November 12th, 1996

Richard Dawkins

You could give Aristotle a tutorial. And you could thrill him to the core of his being. Aristotle was an encyclopedic polymath, an all time intellect. Yet not only can you know more than him about the world. You also can have a deeper understanding of how everything works. Such is the privilege of living after Newton, Darwin, Einstein, Planck, Watson, Crick and their colleagues.

I'm not saying you're more intelligent than Aristotle, or wiser. For all I know, Aristotle's the cleverest person who ever lived. That's not the point. The point is only that science is cumulative, and we live later. Aristotle had a lot to say about astronomy, biology and physics. But his views sound weirdly naive today. Not as soon as we move away from science, however. Aristotle could walk straight into a modern seminar on ethics, theology, political or moral philosophy, and contribute. But let him walk into a modern science class and he'd be a lost soul. Not because of the jargon, but because science advances, cumulatively.

Here's a small sample of the things you could tell Aristotle, or any other Greek philosopher. And surprise and enthral them, not just with the facts themselves but with how they hang together so elegantly.

The earth is not the centre of the universe. It orbits the sun - which is just another star. There is no music of the spheres, but the chemical elements, from which all matter is made, arrange themselves cyclically, in something like octaves. There are not four elements but about 100. Earth, air, fire and water are not among them.

Living species are not isolated types with unchanging essences. Instead, over a time scale too long for humans to imagine, they split and diverge into new species, which then go on diverging further and further. For the first half of geological time our ancestors were bacteria. Most creatures still are bacteria, and each one of our trillions of cells is a colony of bacteria. Aristotle was a distant cousin to a squid, a closer cousin to a monkey, a closer cousin still to an ape (strictly speaking, Aristotle was an ape, an African ape, a closer cousin to a chimpanzee than a chimp is to an orang utan).

The brain is not for cooling the blood. It's what you use to do your logic and your metaphysics. It's a three dimensional maze of a million million nerve cells, each one drawn out like a wire to carry pulsed messages. If you laid all your brain cells end to end, they'd stretch round the world 25 times. There are about 4 million million connections in the tiny brain of a chaffinch, proportionately more in ours.

Now, if you're anything like me, you'll have mixed feelings about that recitation. On the one hand, pride in what Aristotle's species now knows and didn't then. On the other hand an uneasy feeling of, "Isn't it all a bit complacent? What about our descendants, what will they be able to tell us?"

Yes, for sure, the process of accumulation doesn't stop with us. 2000 years hence, ordinary people who have read a couple of books will be in a position to give a tutorial to today's Aristotles: to Francis Crick, say, or Stephen Hawking. So does this mean that our view of the universe will turn out to be just as wrong?

Let's keep a sense of proportion about this! Yes, there's much that we still don't know. But surely our belief that the earth is round and not flat, and that it orbits the sun, will never be superseded. That alone is enough to confound those, endowed with a little philosophical learning, who deny the very possibility of objective truth: those so-called relativists who see no reason to prefer scientific views over aboriginal myths about the world.

Our belief that we share ancestors with chimpanzees, and more distant ancestors with monkeys, will never be superseded although details of timing may change. Many of our ideas, on the other hand, are still best seen as theories or models whose predictions, so far, have survived the test. Physicists disagree over whether they are condemned forever to dig for deeper mysteries, or whether physics itself will come to an end in a final 'theory of everything', a nirvana of knowledge. Meanwhile, there is so much that we don't yet understand, we should loudly proclaim those things that we do, so as to focus attention on problems that we should be working on.

Far from being over-confident, many scientists believe that science advances only by disproof of its hypotheses. Konrad Lorenz said he hoped to disprove at least one of his own hypotheses every day before breakfast. That was absurd, especially coming from the grand old man of the science of ethology, but it is true that scientists, more than others, impress their peers by admitting their mistakes.

A formative influence on my undergraduate self was the response of a respected elder statesmen of the Oxford Zoology Department when an American visitor had just publicly disproved his favourite theory. The old man strode to the front of the lecture hall, shook the American warmly by the hand and declared in ringing, emotional tones: "My dear fellow, I wish to thank you. I have been wrong these fifteen years." And we clapped our hands red. Can you imagine a Government Minister being cheered in the House of Commons for a similar admission? "Resign, Resign" is a much more likely response!

Yet there is hostility towards science. And not just from the green ink underlining brigade, but from published novelists and newspaper columnists. Newspaper columns are notoriously ephemeral, but their drip drip, week after week, or day after day, repetition gives them influence and power, and we have to notice them. A peculiar feature of the British press is the regularity with which some of its leading columnists return to attack science - and not always from a vantage point of knowledge. A few weeks ago, Bernard Levin's effusion in The Times was entitled "God, me and Dr Dawkins" and it had the subtitle: "Scientists don't know and nor do I - but at least I know I don't know".

It is no mean task to plumb the full depths of what Mr Bernard Levin does not know, but here's an illustration of the gusto with which he boasts of it.

"Despite their access to copious research funds, today's scientists have yet to prove that a quark is worth a bag of beans. The quarks are coming! The quarks are coming! Run for your lives . . .! Yes, I know I shouldn't jeer at science, noble science, which, after all, gave us mobile telephones, collapsible umbrellas and multi-striped toothpaste, but science really does ask for it . . . Now I must be serious. Can you eat quarks? Can you spread them on your bed when the cold weather comes?"

It doesn't deserve a reply, but the distinguished Cambridge scientist, Sir Alan Cottrell, wrote a brief Letter to the Editor:- "Sir: Mr Bernard Levin asks 'Can you eat quarks?' I estimate that he eats 500,000,000, 000,000, 000,000 quarks a day."

It has become almost a clichЋ to remark that nobody boasts of ignorance of literature, but it is socially acceptable to boast ignorance of science and proudly claim incompetence in mathematics. In Britain, that is. I believe the same is not true of our more successful economic competitors, Germany, the United States and Japan.

People certainly blame science for nuclear weapons and similar horrors.

It's been said before but needs to be said again: if you want to do evil, science provides the most powerful weapons to do evil; but equally, if you want to do good, science puts into your hands the most powerful tools to do so. The trick is to want the right things, then science will provide you with the most effective methods of achieving them.
An equally common accusation is that science goes beyond its remit. It's accused of a grasping take-over bid for territory that properly belongs to other disciplines such as theology. On the other hand - you can't win! - listen to the novelist Fay Weldon's hymn of hate against 'the scientists' in The Daily Telegraph.
"Don't expect us to like you. You promised us too much and failed to deliver. You never even tried to answer the questions we all asked when we were six. Where did Aunt Maud go when she died? Where was she before she was born? . . . And who cares about half a second after the Big Bang; what about half a second before? And what about crop circles?"
More than some of my colleagues, I am perfectly happy to give a simple and direct answer to both those Aunt Maud questions. But I'd certainly be called arrogant and presumptuous, going beyond the limits of science.
Then there's the view that science is dull and plodding, with rows of biros in its top pocket. Here's another newspaper columnist, A A Gill, writing on science this year in The Sunday Times.
"Science is constrained by experiment results and the tedious, plodding stepping stones of empiricism . . . What appears on television just is more exciting than what goes on in the back of it . . . That's art, luvvie: theatre, magic, fairy dust, imagination, lights, music, applause, my public. There are stars and there are stars, darling. Some are dull, repetitive squiggles on paper, and some are fabulous, witty, thought-provoking, incredibly popular . . ."
The 'dull, repetitive squiggles' is a reference to the discovery of pulsars in 1967, by Jocelyn Bell and Anthony Hewish. Jocelyn Bell Burnell had recounted on television the spine-tingling moment when, a young woman on the threshold of a career, she first knew she was in the presence of something hitherto unheard-of in the universe. Not something new under the sun, a whole new KIND of sun, which rotates, so fast that, instead of taking 24 hours like our planet, it takes a quarter of a second. Darling, how too plodding, how madly empirical my dear!
Could science just be too difficult for some people, and therefore seem threatening? Oddly enough, I wouldn't dare to make such a suggestion, but I am happy to quote a distinguished literary scholar, John Carey, the present Merton Professor of English at Oxford:
"The annual hordes competing for places on arts courses in British universities, and the trickle of science applicants, testify to the abandonment of science among the young. Though most academics are wary of saying it straight out, the general consensus seems to be that arts courses are popular because they are easier, and that most arts students would simply not be up to the intellectual demands of a science course."
My own view is that the sciences can be intellectually demanding, but so can classics, so can history, so can philosophy. On the other hand, nobody should have trouble understanding things like the circulation of the blood and the heart's role in pumping it round. Carey quoted Donne's lines to a class of 30 undergraduates in their final year reading English at Oxford:
"Knows't thou how blood, which to the heart doth flow,
Doth from one ventricle to the other go?"

Carey asked them how, as a matter of fact, the blood does flow. None of the thirty could answer, and one tentatively guessed that it might be 'by osmosis'. The truth - that the blood is pumped from ventricle to ventricle through at least 50 miles of intricately dissected capillary vessels throughout the body - should fascinate any true literary scholar. And unlike, say, quantum theory or relativity, it isn't hard to understand. So I tender a more charitable view than Professor Carey. I wonder whether

some of these young people might have been positively turned off science. Last month I had a letter from a television viewer who poignantly began: "I am a clarinet teacher whose only memory of science at school was a long period of studying the Bunsen burner." Now, you can enjoy the Mozart concerto without being able to play the clarinet. You can be a discerning and informed concert critic without being able to play a note. Of course music would come to a halt if nobody learned to play it. But if everybody left school thinking you had to play an intrument before you could appreciate music, think how impoverished many lives would be.
Couldn't we treat science in the same way? Yes, we must have Bunsen burners and dissecting needles for those drawn to advanced scientific practice. But perhaps the rest if us could have separate classes in science appreciation, the wonder of science, scientific ways of thinking, and the history of scientific ideas, rather than laboratory experience.
It's here that I'd seek rapprochement with another apparent foe of science, Simon Jenkins, former editor of The Times and a much more formidable adversary than the other journalists I've quoted, because he has some knowledge of what he is talking about. He resents compulsory science education and he holds the idiosyncratic view that it isn't useful. But he is thoroughly sound on the uplifting qualities of science. In a recorded conversation with me, he said:
"I can think of very few science books I've read that I've called useful. What they've been is wonderful. They've actually made me feel that the world around me is a much fuller . . . much more awesome place than I ever realised it was . . . I think that science has got a wonderful story to tell. But it isn't useful. It's not useful like a course in business studies or law is useful, or even a course in politics and economics."
Far from science not being useful, my worry is that it is so useful as to overshadow and distract from its inspirational and cultural value. Usually even its sternest critics concede the usefulness of science, while completely missing the wonder. Science is often said to undermine our humanity, or destroy the mystery on which poetry is thought to thrive.
Keats berated Newton for destroying the poetry of the rainbow.

"Philosophy will clip an Angel's wings,
Conquer all mysteries by rule and line,
Empty the haunted air, and gnomed mine -
Unweave a rainbow . . ."

Keats was, of course, a very young man.
Blake, too, lamented:

"For Bacon and Newton, sheath'd in dismal steel, their terrors hang
Like iron scourges over Albion; Reasonings like vast Serpents
Infold around my limbs . . ."

I wish I could meet Keats or Blake to persuade them that mysteries don't lose their poetry because they are solved. Quite the contrary. The solution often turns out more beautiful than the puzzle, and anyway the solution uncovers deeper mystery. The rainbow's dissection into light of different wavelengths leads on to Maxwell's equations, and eventually to special relativity.
Einstein himself was openly ruled by an aesthetic scientific muse: "The most beautiful thing we can experience is the mysterious. It is the source of all true art and science", he said. It's hard to find a modern particle physicist who doesn't own to some such aesthetic motivation. Typical is John Wheeler, one of the distinguished elder statesmen of American physics today:
" . . . we will grasp the central idea of it all as so simple, so beautiful, so compelling that we will all say each to the other, 'Oh, how could it have been otherwise! How could we all have been so blind for so long!'"
Wordsworth might have understood this better than his fellow romantics. He

looked forward to a time when scientific discoveries would become "proper objects of the poet's art". And, at the painter Benjamin Haydon's dinner of 1817, he endeared himself to scientists, and endured the taunts of Keats and Charles Lamb, by refusing to join in their toast: "Confusion to mathematics and Newton".

Now, here's an apparent confusion: T H Huxley saw science as "nothing but trained and organized common sense", while Professor Lewis Wolpert insists that it's deeply paradoxical and surprising, an affront to commonsense rather than an extension of it. Every time you drink a glass of water, you are probably imbibing at least one atom that passed through the bladder of Aristotle. A tantalisingly surprising result, but it follows by Huxley-style organized common sense from Wolpert's observation that "there are many more molecules in a glass of water than there are glasses of water in the sea".

Science runs the gamut from the tantalisingly surprising to the deeply strange, and ideas don't come any stranger than Quantum Mechanics. More than one physicist has said something like: "If you think you understand quantum theory, you don't understand quantum theory."

There is mystery in the universe, beguiling mystery, but it isn't capricious, whimsical, frivolous in its changeability. The universe is an orderly place and, at a deep level, regions of it behave like other regions, times behave like other times. If you put a brick on a table it stays there unless something lawfully moves it, even if you meanwhile forget it's there. Poltergeists and sprites don't intervene and hurl it about for reasons of mischief or caprice. There is mystery but not magic, strangeness beyond the wildest imagining, but no spells or witchery, no arbitrary miracles.

Even science fiction, though it may tinker with the laws of nature, can't abolish lawfulness itself and remain good science fiction. Young women don't take off their clothes and spontaneously morph themselves into wolves. A recent television drama is fairytale rather than science fiction, for this reason. It falls foul of a theoretical prohibition much deeper than the philosopher's "All swans are white - until a black one turns up" inductive reasoning. We know people can't metamorphose into wolves, not because the phenomenon has never been observed - plenty of things happen for the first time - but because werewolves would violate the equivalent of the second law of thermodynamics. Of this, Sir Arthur Eddington said.

"If someone points out to you that your pet theory of the universe is in disagreement with Maxwell's equations - then so much the worse for Maxwell's equations. If it is found to be contradicted by observation - well, these experimentalists do bungle things sometimes. But if your theory is found to be against the second law of thermodynamics I can give you no hope; there is nothing for it but to collapse in deepest humiliation."

To pursue the relationship between werewolves and entropy would take me too far afield. But, since this lecture commemorates a man whose integrity and honesty as a broadcaster is still an abiding legend 30 years after his death, I'll stay for a moment with the current epidemic of paranormal propaganda on television.

In one popular type of programming, conjurers come on and do routine tricks. But instead of admitting that they are conjurers, these television performers claim genuinely supernatural powers. In this they are abetted by prestigious, even knighted, presenters, people whom we have got into the habit of trusting, broadcasters who have become role models. It is an abuse of what might be called the Richard Dimbleby Effect.

In other programmes, disturbed people recount their fantasies of ghosts and poltergeists. But instead of sending them off to a kindly psychiatrist, television producers eagerly hire actors to re-create their delusions - with predictable effects on the credulity of large audiences.

Recently, a faith healer was given half an hour of free prime time television, to advertise his bizarre claim to be a 2000 year-dead physician called Paul of Judea. Some might call this entertainment, comedy even, though others would find it objectionable entertainment, like a fairground freak show.

Now I obviously have to return to the arrogance problem. How can I be so sure that this ordinary Englishman with an unlikely foreign accent was not the long dead Paul of Judea? How do I know that astrology doesn't work? How can I be so confident that the television 'supernaturalists' are ordinary conjurers, just because ordinary conjurers can replicate their tricks? (spoonbending, by the way, is so routine a trick that the American conjurers Penn and Teller have posted instructions for doing it on the Internet! See http://www.randi.org/jr/ptspoon.html).

It really comes down to parsimony, economy of explanation. It is possible that your car engine is driven by psychokinetic energy, but if it looks like a petrol engine, smells like a petrol engine and performs exactly as well as a petrol engine, the sensible working hypothesis is that it is a petrol engine. Telepathy and possession by the spirits of the dead are not ruled out as a matter of principle. There is certainly nothing impossible about abduction by aliens in UFOs. One day it may be happen. But on grounds of probability it should be kept as an explanation of last resort. It is unparsimonious, demanding more than routinely weak evidence before we should believe it. If you hear hooves clip-clopping down a London street, it could be a zebra or even a unicorn, but, before we assume that it's anything other than a horse, we should demand a certain minimal standard of evidence.

It's been suggested that if the supernaturalists really had the powers they claim, they'd win the lottery every week. I prefer to point out that they could also win a Nobel Prize for discovering fundamental physical forces hitherto unknown to science. Either way, why are they wasting their talents doing party turns on television?

By all means let's be open-minded, but not so open-minded that our brains drop out. I'm not asking for all such programmes to be suppressed, merely that the audience should be encouraged to be critical. In the case of the psychokineticists and thought-readers, it would be good entertainment to invite studio audiences to suggest critical tests, which only genuine psychics, but not ordinary conjurers, could pass. It would make a good, entertaining form of quiz show.

How do we account for the current paranormal vogue in the popular media? Perhaps it has something to do with the millennium - in which case it's depressing to realise that the millennium is still three years away. Less portentously, it may be an attempt to cash in on the success of The X-Files. This is fiction and therefore defensible as pure entertainment.

A fair defence, you might think. But soap operas, cop series and the like are justly criticised if, week after week, they ram home the same prejudice or bias. Each week The X-Files poses a mystery and offers two rival kinds of explanation, the rational theory and the paranormal theory. And, week after week, the rational explanation loses. But it is only fiction, a bit of fun, why get so hot under the collar?

Imagine a crime series in which, every week, there is a white suspect and a black suspect. And every week, lo and behold, the black one turns out to have done it. Unpardonable, of course. And my point is that you could not defend it by saying: "But it's only fiction, only entertainment".

Let's not go back to a dark age of superstition and unreason, a world in which every time you lose your keys you suspect poltergeists, demons or alien abduction.

Enough, let me turn to happier matters. The popularity of the paranormal, oddly enough, might even be grounds for encouragement . I think that the appetite for mystery, the enthusiasm for that which we do not understand, is healthy and to be fostered. It is the same appetite which drives the best of true science, and it is an appetite which true science is best qualified to satisfy. Perhaps it is this appetite that underlies the ratings success of the paranormalists.

I believe that astrologers, for instance, are playing on - misusing, abusing - our sense of wonder. I mean when they hijack the constellations, and employ sub-poetic language like the moon moving into the fifth house of Aquarius. Real astronomy is the rightful proprietor of the stars and their wonder. Astrology gets in the way, even subverts and debauches the wonder.

To show how real astronomical wonder can be presented to children, I'll borrow from a book called Earthsearch by John Cassidy, which I brought back from America to show my daughter Juliet. Find a large open space and take a soccer ball to represent the sun. Put the ball down and walk ten paces in a straight line. Stick a pin in the ground. The head of the pin stands for the planet Mercury. Take another 9 paces beyond Mercury and put down a peppercorn to represent Venus. Seven paces on, drop another peppercorn for Earth. One inch away from earth, another pinhead represents the Moon, the furthest place, remember, that we've so far reached. 14 more paces to little Mars, then 95 paces to giant Jupiter, a ping-pong ball. 112 paces further, Saturn is a marble. No time to deal with the outer planets except to say that the distances are much larger. But, how far would you have to walk to reach the nearest star, Proxima Centauri? Pick up another soccer ball to represent it, and set off for a walk of 4200 miles. As for the nearest other galaxy, Andromeda, don't even think about it!

Who'd go back to astrology when they've sampled the real thing - astronomy, Yeats's "starry ways", his "lonely, majestical multitude"? The same lovely poem encourages us to "Remember the wisdom out of the old days" and I want to end with a little piece of wonder from my own territory of evolution.

You contain a trillion copies of a large, textual document written in a highly accurate, digital code, each copy as voluminous as a substantial book. I'm talking, of course, of the DNA in your cells. Textbooks describe DNA as a blueprint for a body. It's better seen as a recipe for making a body, because it is irreversible. But today I want to present it as something different again, and even more intriguing. The DNA in you is a coded description of ancient worlds in which your ancestors lived. DNA is the wisdom out of the old days, and I mean very old days indeed.

The oldest human documents go back a few thousand years, originally written in pictures. Alphabets seem to have been invented about 35 centuries ago in the Middle East, and they've changed and spawned numerous varieties of alphabet since then. The DNA alphabet arose at least 35 million centuries ago. Since that time, it hasn't change one jot. Not just the alphabet, the dictionary of 64 basic words and their meanings is the same in modern bacteria and in us. Yet the common ancestor from whom we both inherited this precise and accurate dictionary lived at least 35 million centuries ago.

What changes is the long programs that natural selection has written using those 64 basic words. The messages that have come down to us are the ones that have survived millions, in some cases hundreds of millions, of generations. For every successful message that has reached the present, countless failures have fallen away like the chippings on a sculptor's floor. That's what Darwinian natural selection means. We are the descendants of a tiny Ћlite of successful ancestors. Our DNA has proved itself successful, because it is here. Geological time has carved and sculpted our DNA to survive down to the present.

There are perhaps 30 million distinct species in the world today. So, there are 30 million distinct ways of making a living, ways of working to pass DNA on to the future. Some do it in the sea, some on land. Some up trees, some underground. Some are plants, using solar panels - we call them leaves - to trap energy. Some eat the plants. Some eat the herbivores. Some are big carnivores that eat the small ones. Some live as parasites inside other bodies. Some live in hot springs. One species of small worms is said to live entirely inside German beer mats. All these different ways of making a living are just different tactics for passing on DNA. The differences are in the details.

The DNA of a camel was once in the sea, but it hasn't been there for a good 300 million years. It has spent most of recent geological history in deserts, programming bodies to withstand dust and conserve water. Like sandbluffs carved into fantastic shapes by the desert winds, camel DNA has been sculpted by survival in ancient deserts to yield modern camels.

At every stage of its geological apprenticeship, the DNA of a species has been honed and whittled, carved and rejigged by selection in a succession of environments. If only we could read the language, the DNA of tuna and starfish would have 'sea' written into the text. The DNA of moles and earthworms would spell 'underground'. Of course all the DNA would spell many other things as well. Shark and cheetah DNA would spell 'hunt', as well as separate messages about sea and land.

We can't read these messages yet. Maybe we never shall, for their language is indirect, as befits a recipe rather than a reversible blueprint. But it's still true that our DNA is a coded description of the worlds in which our ancestors survived. We are walking archives of the African Pliocene, even of Devonian seas, walking repositories of wisdom out of the old days. You could spend a lifetime reading such messages and die unsated by the wonder of it.

We are going to die, and that makes us the lucky ones. Most people are never going to die because they are never going to be born. The potential people who could have been standing in my place but who will never see the light of day outnumber the sand grains of Sahara - more, the atoms in the universe. Certainly those unborn ghosts include greater poets than Donne, greater scientists than Newton, greater composers than Beethoven. We know this because the set of possible people allowed by our DNA so massively outnumbers the set of actual people. In the teeth of these stupefying odds it is you and I that are privileged to be here, privileged with eyes to see where we are and brains to wonder why.

There is an appetite for wonder, and isn't true science well qualified to feed it?

It's often said that people 'need' something more in their lives than just the material world. There is a gap that must be filled. People need to feel a sense of purpose. Well, not a BAD purpose would be to find out what is already here, in the material world, before concluding that you need something more. How much more do you want? Just study what is, and you'll find that it already is far more uplifting than anything you could imagine needing.

You don't have to be a scientist - you don't have to play the bunsen burner - in order to understand enough science to overtake your imagined need and fill that fancied gap. Science needs to be released from the lab into the culture.

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Good And Bad Reasons For Believing

Richard Dawkins

Dear Juliet,
Now that you are ten, I want to write to you about something that is important to me. Have you ever wondered how we know the things that we know? How do we know, for instance, that the stars, which look like tiny pinpricks in the sky, are really huge balls of fire like the sun and are very far away? And how do we know that Earth is a smaller ball whirling round one of those stars, the sun? The answer to these questions is "evidence." Sometimes evidence means actually seeing (or hearing, feeling, smelling.....) that something is true. Astronauts have travelled far enough from earth to see with their own eyes that it is round. Sometimes our eyes need help. The "evening star" looks like a bright twinkle in the sky, but with a telescope, you can see that it is a beautiful ball - the planet we call Venus. Something that you learn by direct seeing (or hearing or feeling.....) is called an observation.
Often, evidence isn't just an observation on its own, but observation always lies at the back of it. If there's been a murder, often nobody (except the murderer and the victim!) actually observed it. But detectives can gather together lots or other observations which may all point toward a particular suspect. If a person's fingerprints match those found on a dagger, this is evidence that he touched it. It doesn't prove that he did the murder, but it can help when it's joined up with lots of other evidence. Sometimes a detective can think about a whole lot of observations and suddenly realise that they fall into place and make sense if so-and-so did the murder.
Scientists - the specialists in discovering what is true about the world and the universe - often work like detectives. They make a guess (called a hypothesis) about what might be true. They then say to themselves: If that were really true, we ought to see so-and-so. This is called a prediction. For example, if the world is really round, we can predict that a traveller, going on and on in the same direction, should eventually find himself back where he started.When a doctor says that you have the measles, he doesn't take one look at you and see measles. His first look gives him a hypothesis that you may have measles. Then he says to himself: If she has measles I ought to see...... Then he runs through the list of predictions and tests them with his eyes (have you got spots?); hands (is your forehead hot?); and ears (does your chest wheeze in a measly way?). Only then does he make his decision and say, " I diagnose that the child has measles. " Sometimes doctors need to do other tests like blood tests or X-Rays, which help their eyes, hands, and ears to make observations.
The way scientists use evidence to learn about the world is much cleverer and more complicated than I can say in a short letter. But now I want to move on from evidence, which is a good reason for believing something , and warn you against three bad reasons for believing anything. They are called "tradition," "authority," and "revelation."
First, tradition. A few months ago, I went on television to have a discussion with about fifty children. These children were invited because they had been brought up in lots of different religions. Some had been brought up as Christians, others as Jews, Muslims, Hindus, or Sikhs. The man with the microphone went from child to child, asking them what they believed. What they said shows up exactly what I mean by "tradition." Their beliefs turned out to have no connection with evidence. They just trotted out the beliefs of their

parents and grandparents which, in turn, were not based upon evidence either. They said things like: "We Hindus believe so and so"; "We Muslims believe such and such"; "We Christians believe something else."

Of course, since they all believed different things, they couldn't all be right. The man with the microphone seemed to think this quite right and proper, and he didn't even try to get them to argue out their differences with each other. But that isn't the point I want to make for the moment. I simply want to ask where their beliefs come from. They came from tradition. Tradition means beliefs handed down from grandparent to parent to child, and so on. Or from books handed down through the centuries. Traditional beliefs often start from almost nothing; perhaps somebody just makes them up originally, like the stories about Thor and Zeus. But after they've been handed down over some centuries, the mere fact that they are so old makes them seem special. People believe things simply because people have believed the same thing over the centuries. That's tradition.

The trouble with tradition is that, no matter how long ago a story was made up, it is still exactly as true or untrue as the original story was. If you make up a story that isn't true, handing it down over a number of centuries doesn't make it any truer!

Most people in England have been baptised into the Church of England, but this is only one of the branches of the Christian religion. There are other branches such as Russian Orthodox, the Roman Catholic, and the Methodist churches. They all believe different things. The Jewish religion and the Muslim religion are a bit more different still; and there are different kinds of Jews and of Muslims. People who believe even slightly different things from each other go to war over their disagreements. So you might think that they must have some pretty good reasons - evidence - for believing what they believe. But actually, their different beliefs are entirely due to different traditions.

Let's talk about one particular tradition. Roman Catholics believe that Mary, the mother of Jesus, was so special that she didn't die but was lifted bodily in to Heaven. Other Christian traditions disagree, saying that Mary did die like anybody else. These other religions don't talk about much and, unlike Roman Catholics, they don't call her the "Queen of Heaven." The tradition that Mary's body was lifted into Heaven is not an old one. The bible says nothing on how she died; in fact, the poor woman is scarcely mentioned in the Bible at all. The belief that her body was lifted into Heaven wasn't invented until about six centuries after Jesus' time. At first, it was just made up, in the same way as any story like "Snow White" was made up. But, over the centuries, it grew into a tradition and people started to take it seriously simply because the story had been handed down over so many generations. The older the tradition became, the more people took it seriously. It finally was written down as and official Roman Catholic belief only very recently, in 1950, when I was the age you are now. But the story was no more true in 1950 than it was when it was first invented six hundred years after Mary's death.

I'll come back to tradition at the end of my letter, and look at it in another way. But first, I must deal with the two other bad reasons for believing in anything: authority and revelation.

Authority, as a reason for believing something, means believing in it because you are told to believe it by somebody important. In the Roman Catholic Church, the pope is the most important person, and people believe he must be right just because he is the pope. In one branch of the Muslim religion, the important people are the old men with beards called ayatollahs. Lots of Muslims in this country are prepared to commit murder, purely because the ayatollahs in a faraway country tell them to.

When I say that it was only in 1950 that Roman Catholics were finally told that they had to believe that Mary's body shot off to Heaven, what I mean is that in 1950, the pope told people that they had to believe it. That was it. The pope said it was true, so it had to be true! Now, probably some of the things that that pope said in his life were true and some were not true. There is no good reason why, just because he was the pope, you should believe everything he said any more than you believe everything that other people say. The present pope (1995) has ordered his followers not to limit the number of babies they have. If people follow this authority as slavishly as he would wish, the results could be terrible famines, diseases, and wars, caused by overcrowding.

Of course, even in science, sometimes we haven't seen the evidence ourselves and we have to take somebody else's word for it. I haven't, with my own eyes, seen the evidence that light travels at a speed of 186,000 miles per second. Instead, I believe books that tell me the speed of light. This looks like "authority." But actually, it is much better than authority, because the people who wrote the books have seen the evidence and anyone is free to look carefully at the evidence whenever they want. That is very comforting. But not even the priests claim that there is any evidence for their story about Mary's body zooming off to Heaven.

The third kind of bad reason for believing anything is called "revelation." If you had asked the pope in 1950 how he knew that Mary's body disappeared into Heaven, he would probably have said that it had been "revealed" to him. He shut himself in his room and prayed for guidance. He thought and thought, all by himself, and he became more and more sure inside himself. When religious people just have a feeling inside themselves that something must be true, even though there is no evidence that it is true, they call their feeling "revelation." It isn't only popes who claim to have revelations. Lots of religious people do. It is one of their main reasons for believing the things that they do believe. But is it a good reason?

Suppose I told you that your dog was dead. You'd be very upset, and you'd probably say, "Are you sure? How do you know? How did it happen?" Now suppose I answered: "I don't actually know that Pepe is dead. I have no evidence. I just have a funny feeling deep inside me that he is dead." You'd be pretty cross with me for scaring you, because you'd know that an inside "feeling" on its own is not a good reason for believing that a whippet is dead. You need evidence. We all have inside feelings from time to time, sometimes they turn out to be right and sometimes they don't. Anyway, different people have opposite feelings, so how are we to decide whose feeling is right? The only way to be sure that a dog is dead is to see him dead, or hear that his heart has stopped; or be told by somebody who has seen or heard some real evidence that he is dead.

People sometimes say that you must believe in feelings deep inside, otherwise, you' d never be confident of things like "My wife loves me." But this is a bad argument. There can be plenty of evidence that somebody loves you. All through the day when you are with somebody who loves you, you see and hear lots of little titbits of evidence, and they all add up. It isn't a purely inside feeling, like the feeling that priests call revelation. There are outside things to back up the inside feeling: looks in the eye, tender notes in the voice, little favors and kindnesses; this is all real evidence.

Sometimes people have a strong inside feeling that somebody loves them when it is not based upon any evidence, and then they are likely to be completely wrong. There are people with a strong inside feeling that a famous film star loves them, when really the film star hasn't even met them. People like that are ill in their minds. Inside feelings must be backed up by evidence, otherwise you just can't trust them.

Inside feelings are valuable in science, too, but only for giving you ideas that you later test by looking for evidence. A scientist can have a "hunch'" about an idea that just "feels" right. In itself, this is not a good reason for believing something. But it can be a good reason for spending some time doing a particular experiment, or looking in a particular way for evidence. Scientists use inside feelings all the time to get ideas. But they are not worth anything until they are supported by evidence.

I promised that I'd come back to tradition, and look at it in another way. I want to try to explain why tradition is so important to us. All animals are built (by the process called evolution) to survive in the normal place in which their kind live. Lions are built to be good at surviving on the plains of Africa. Crayfish to be good at surviving in fresh, water, while lobsters are built to be good at surviving in the salt sea. People are animals, too, and we are built to be good at surviving in a world full of ..... other people. Most of us don't hunt for our own food like lions or lobsters; we buy it from other people who have bought it from yet other people. We ''swim'' through a "sea of people." Just as a fish needs gills to survive in water, people need brains that make them able to deal with other people. Just as the sea is full of salt water, the sea of people is full of difficult things to learn. Like language.

You speak English, but your friend Ann-Kathrin speaks German. You each speak the language that fits you to '`swim about" in your own separate "people sea." Language is passed down by tradition. There is no other way . In England, Pepe is a dog. In Germany he is ein Hund. Neither of these words is more correct, or more true than the other. Both are simply handed down. In order to be good at "swimming about in their people sea," children have to learn the language of their own country, and lots of other things about their own people; and this means that they have to absorb, like blotting paper, an enormous amount of traditional information. (Remember that traditional information just means things that are handed down from grandparents to parents to children.) The child's brain has to be a sucker for traditional information. And the child can't be expected to sort out good and useful traditional information, like the words of a language, from bad or silly traditional information, like believing in witches and devils and ever-living virgins.

It's a pity, but it can't help being the case, that because children have to be suckers for traditional information, they are likely to believe anything the grown-ups tell them, whether true or false, right or wrong. Lots of what the grown-ups tell them is true and based on evidence, or at least sensible. But if some of it is false, silly, or even wicked, there is nothing to stop the children believing that, too. Now, when the children grow up, what do they do? Well, of course, they tell it to the next generation of children. So, once something gets itself strongly believed - even if it is completely untrue and there never was any reason to believe it in the first place - it can go on forever.

Could this be what has happened with religions ? Belief that there is a god or gods, belief in Heaven, belief that Mary never died, belief that Jesus never had a human father, belief that prayers are answered, belief that wine turns into blood - not one of these beliefs is backed up by any good evidence. Yet millions of people believe them. Perhaps this because they were told to believe them when they were told to believe them when they were young enough to believe anything. Millions of other people believe quite different things, because they were told different things when they were children. Muslim children are told different things from Christian children, and both grow up utterly convinced that they are right and the others are wrong. Even within Christians, Roman Catholics believe different things from Church of England people or Episcopalians, Shakers or Quakers , Mormons or Holy Rollers, and are all utterly covinced that they are right and the others are wrong. They believe different things for exactly the same kind of reason as you speak English and Ann-Kathrin speaks German. Both languages are, in their own country, the right language to speak. But it can't be true that different religions are right in their own countries, because different religions claim that opposite things are true. Mary can't be alive in Catholic Southern Ireland but dead in Protestant Northern Ireland.

What can we do about all this ? It is not easy for you to do anything, because you are only ten. But you could try this. Next time somebody tells you something that sounds important, think to yourself: "Is this the kind of thing that people probably know because of evidence? Or is it the kind of thing that people only believe because of tradition, authority, or revelation?" And, next time somebody tells you that something is true, why not say to them: "What kind of evidence is there for that?" And if they can't give you a good answer, I hope you'll think very carefully before you believe a word they say.

Your loving
Daddy

RICHARD DAWKINS is an evolutionary biologist; reader in the Department of Zoology at Oxford University; fellow of New College. He began his research career in the 1960s as a research student with Nobel Prize-winning ethologist Nico Tinbergen, and ever since then, his work has largely been concerned with the evolution of behavior. Since 1976, when his first book, The Selfish Gene, encapsulated both the substance and the spirit of what is now called the sociobiological revolution, he has become widely known, both for the originality of his ideas and for the clarity and elegance with which he expounds them. A subsequent book, The Extended Phenotype, and a number of television programs, have extended the notion of the gene as the unit of selection, and have applied it to biological examples as various as the relationship between hosts and parasites and the evolution of cooperation. His following book, The Blind Watchmaker, is widely read, widely quoted, and one of the truly influential intellectual works of our time. He is also author of the recently published River Out of Eden.

Further Reading

How Things Are: A Science Toolkit for the Mind
Edited by John Brockman and Katinka Matson

Richard Dawkins'
Evolution
by Ian Parker

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Go to The World of Zoologist Richard Dawkins

Richard Dawkins, arch-Darwinist, author of "The Selfish Gene", and Britain's village atheist, has a reputation for intellectual austerity and single-mindedness: he is a professor who will not stop professing. Because he knows the meaning of life (which is evolution by natural selection), and because others do not know it, or only half know it, or try willfully to mess with its simple, delicious truth, he promotes his subject in a way that -- if you wanted to drive him crazy -- you could call evangelical. Besides writing his beautifully pellucid and best-selling books on Darwinian themes, Dawkins, who is a zoologist by training, is forever finding other opportunities to speak on behalf of evolution and on behalf of science. Now in his mid-fifties, he has become a familiar floppy-haired figure on television and in the newspapers, where he energetically scraps with bishops and charlatans. He recently argued, for example, that astrologers should be jailed, and he has complained warmly about what he alleges are one novelist's slurs on his profession. ("Sir," he wrote to the Daily Telegraph, "Fay Weldon's incoherent, petulant and nihilistic rant is the sort of thing I remember scribbling as a disgruntled teenager.") Dawkins regards it as his duty not to let things pass, or rest, and as he makes his slightly awkward -- but still dashing -- progress through the British media he occasionally encounters charges of arrogance and aggressiveness. It is not universally agreed that he is science's ideal public-relations director.

This, though, is now his job. Dawkins has been appointed the first Charles Simonyi Professor of Public Understanding of Science at Oxford University -- Simonyi, the sponsor, being a soft-spoken Hungarian-born American made rich by long employment at Microsoft. Dawkins will now be expected to do more of what he has been doing: to write books, appear on television, and help counter what he calls "the stereo- type of scientists' being scruffy nerds with rows of pens in their top pocket" -- an image that he regards, with a typical level of moderation, as "just about as wicked as racist stereotypes." Richard Dawkins has been made the new Oxford Professor of Being Richard Dawkins.

Because of all his media activity -- those bright, staring eyes on television -- it has sometimes been possible to forget that Dawkins's reputation is founded on a remarkable writing achievement. Twenty years ago, with "The Selfish Gene" (1976), Dawkins managed to secure a wildly enthusiastic general readership for writing that was also of interest to his professional colleagues: he seduced two audiences at once. Biologists found themselves learning about their subject not from a paper in a learned journal but -- as in an earlier tradition of scientific disclosure, one that includes Darvin's own work -- from a book reviewed in the Sunday press. His later books, "The Blind Watchmaker" (1986) and "River Out of Eden" (1995), had a similar effect.

Like so much of Dawkins's enterprise, the inspiration for "The Selfish Gene" was rebuttal: the book was designed to banish an infuriatingly widespread popular misconception about evolution. The misconception was that Darwinian selection worked at the level of the group or the species, that it had something to do with the balance of nature. How else could one understand, for example, the evolution of apparent "altruism" in animal behavior? How could self-sacrifice, or niceness, ever have been favored by natural selection? There were answers to these questions, and they had been recently developed, in particular, by the evolutionary biologists W. D. Hamilton, now at Oxford, and George Williams, of the State University of New York at Stony Brook. But their answers were muted. Dawkins has written, "For me, their insight had a visionary quality. But I found their expressions of it too laconic, not full-throated enough. I was convinced that an amplified and developed version could make everything about life fall into place, in the heart as well as in the brain."

Essentially, their insight was that altruism in nature was a trick of the light. Once one understands that evolution works at the level of the gene -- a process of gene survival, taking place (as Dawkins developed it) in bodies that the gene occupies and then discards -- the problem of altruism begins to disappear. Evolution favors strategies that cause as many of an animal's genes as possible to survive -- strategies that may not immediately appear to be evolutionarily sound. In the idea's simplest form, if an animal puts its life at risk for its offspring, it is preserving a creature -- gene "vehicle," in Dawkins's language -- half of whose genes are its own. This is a sensible, selfish strategy, despite the possible inconvenience of death. No one is being nice.

Starting from this point, "The Selfish Gene" took its reader into more complex areas of animal behavior, where more persuasion was needed -- more mathematics, sometimes, and more daring logical journeys. Dawkins assumed no prior knowledge of the subject in his reader, yet was true to his science. He made occasional ventures into ambitious prose (genes "swarm in huge colonies, safe inside gigantic lumbering robots"), but mostly relied on sustained clarity, the taming of large numbers, and the judicious use of metaphor. The result was exhilarating. Upon the book's publication, the Times called it "the sort of popular science writing that makes the reader feel like a genius." Douglas Adams, a friend of Dawkins's and the author of "The Hitchhiker's Guide to the Galaxy," found the experience of reading it "one of those absolutely shocking moments of revelation when you understand that the world is fundamentally different from what you thought it was." He adds, "I'm hesitating to use the word, but it's almost like a religious experience."

Twenty Years later, Richard Dawkins finds himself something of a curiosity -- a scientist with an honorary doctorate of letters, a philosopher with a CD-ROM deal, an ambassador who acknowledges that he is "not a diplomat," and a rather reticent man who in print is by turns flamboyantly scornful and boundlessly enthusiastic. I had been told that he "thinks scientifically and only scientifically"so when I recently visited him at his apartment in central Oxford -- he has since moved house -- I was surprised to find a great many wooden carrousel animals there, and a lot of cushions, which made a kind of sitcom chute from chair to floor. It was interesting, too, to note the cupboard by the living-room door, which had been lovingly hand-painted to represent the details of the life of Richard Dawkins: a childhood in Africa, a college room, a computer, a head of Charles Darwin, a young daughter "building castles in the air," and a panel suggesting an international reputation. The cupboard, I learned, was painted by Dawkins's mother, and was a gift to her son on his fiftieth birthday. (He is now fifty-five.) The horses and other large wooden animals were brought into the apartment by Lalla Ward, Dawkins's wife (his third), who inherited the collection. She used to be an actress, and it has caused some joy in the British press that Professor Dawkins is now married to a woman who played the part of an assistant to the television science-fiction character Doctor Who. (It's as if Stephen Jay Gould had married Lieutenant Uhura.)

Having finished with some students, Dawkins now appeared in the living room. A handsome matinee version of an Oxford don, he was wearing leather slippers and blue corduroy trousers. His manner managed to suggest both caution and assurance -- he has something of the air of a bullied schoolboy suddenly made prefect.

We talked about God, and other obstructions to an understanding of science. Dawkins complained of a "fairly common pattern in television news: right at the end a smile comes onto the face of the newsreader and this is the scientific joke -- some scientist has proved that such and such is the case." He went on, "And it's clearly the bit of fun at the end, it's not serious at all. I want science to be taken seriously, because, after all, it's less ephemeral -- it has a more eternal aspect than whatever the politics of the day might be, which, of course, gets the lead in the news."

Much of what is important to others is ephemeral to Dawkins. He shares his life with Darwin's idea -- one that the philosopher Daniel Dennett, of Tufts, has called "the single best idea anyone has ever had." Dawkins does have tastes in art and in politics. He does have friends, and he has become more sociable in recent years. But his non-scientific tastes seem to shrink at the touch of science. He admires Bach's "St. Matthew Passion," but told me, "I really do feel what Bach might have done with some really decent inspiration, considering what he achieved with what he had." He was imagining "Evolution," the oratorio.

While we were talking at his apartment, the telephone rang often. Inevitably, Dawkins was one of the first to be featured in a jokey column in the Guardian called "Celebrity Scholars: A Cut-Out-and-Keep Guide to the Academics Whose Phones Are Always Ringing." He is not a geneticist, but because he once wrote a book that had the word "gene" in the title he is frequently asked to comment on contemporary genetic issues -- the discovery of genes "for" this or that, say, or the ethics of genetic engineering -- and he ordinarily refers journalists to colleagues with the relevant expertise.

Dawkins is still most comfortable dealing with the pure, incontestable logic of Darwinian evolution. His fifth book, "Climbing Mount Improbable," will be published this month in the United States. With a fresh, unifying metaphor, Dawkins here continues his long-term project to make natural selection as Persuasive and comprehensible to others as it is to him. On the peaks of Mount Improbable, he explains, are to be found, say, a spiderweb and the camouflage of a stick insect. It would seem that one has to scale sheer cliffs of improbability to reach such complexity by natural selection. For one thing, natural selection does not Provide for developments that will turn out to be advantageous only after a million years of evolution. What use is a wing stub? What good is a half-evolved eye? But Dawkins points out the long, winding paths that lead to the summit of Mount Improbable -- paths that have the gentlest of slopes and require no freakish upward leaps. He takes his reader up the slope from no eye to eye: a single (not entirely useless) photosensitive cell caused by genetic mutation, a group of such cells, a group arranged on a curve, and so forth. Dawkins knows that the length of this path will always daunt some readers. "Human brains," he writes, "though they sit atop one of its grandest peaks, were never designed to imagine anything as slow as the long march up Mount Improbable."

Dawkins took me to lunch in New College, where he has been a fellow for twenty-six years -- "a bread-and-butter worker," he says. He and Lalla Ward and I sat at a long wooden table in a high-ceilinged room and ate soup with huge silver spoons, and between courses Lalla Ward set herself the task of making a rather introspective-looking college employee return her smile.

As a writer and broadcaster and propagandist, Dawkins has now left the laboratory far behind him. Wondering if this was a source of regret, I asked him if he would exchange what he had achieved for a more traditional scientific discovery. "I'd rather go to my grave having been Watson or Crick than having discovered a wonderful way of explaining things to people," he says. "But if the discovery you're talking about is an ordinary, run-of-the-mill discovery of the sort being made in laboratories around the world every day, you feel: Well, if I hadn't done this, somebody else would have, pretty soon. So if you have a gift for reaching hundreds of thousands -- millions -- of people and enlightening them, I think doing that runs a close second to making a really great discovery like Watson and Crick."

After lunch, we walked back to the apartment, a hundred yards away, passing through a Chinese-style flock of student cyclists. In his cluttered living roorn, Dawkins talked about his past. His father, he said, worked in the British colonial service in Nyasaland, now Malawi, but with the outbreak of the Second World War he moved to Kenya to join the Allied forces. Richard was born in Nairobi, in 1941. In 1946, his father unexpectedly inherited a cousin's farm near Chipping Norton in Oxfordshire, and in 1949 the family returned to England. Dawkins drifted into zoology at Oxford, but he became fully engaged in it only when, some time after his arrival, the speculative nature of the subject revealed itself to him. "I think students of biochemistry, for example, before they can even start, probably have to get a lot of textbook knowledge under their belt," he says. "In animal behavior, you can jump straight into controversy and argument."

While still an undergraduate, Dawkins was taught by Niko Tinbergen, the Dutch-born animal behaviorist (and, later, Nobel Prize winner), who had him read doctoral theses in place of the standard texts. Dawkins remembers reading one thesis about two species of grasshopper, Chorthippus brunneus and Chorthippus biguttulus, that coexist on the European continent and look the same. "The only known difference between them is that they sing differently," he says. "They don't reproduce with each other, bemuse they sing differently. As a consequence of their not reproducing together, they're called two separate species -- and they are. It' s not that they cannot breed but that they do not. Dawkins continues, "In the thesis that I read, the author found it was easy enough to fool them to mate with each other by playing them the song of their own species. And I got a feeling for how you design experiments when you're faced with a problem like this -- and the intellectual importance of this first process in evolution. It happened to be grasshoppers, but it's the same process for all species on earth. They've all diverged from an ancestral species, and that process of divergence is the origin of species -- it's the fundamental process that has given rise to all diversity on earth."

Dawkins graduated in 1962, and started immediately on his doctorate, for which he developed a mathematical model of decision-making in animals. In 1967, he married for the first time, and took up a post as an assistant professor of zoology at Berkeley. He became "a bit involved" in the dramas of the period, he told me. He and his wife marched a little, and worked on Eugene McCarthy's Presidential campaign. (Although colleagues today see Dawkins as apolitical, and enemies have sought to project a right-wing agenda onto his science, he has always voted on the left.) He returned to Oxford after two years and continued research into the mathematics of animal behavior, making much use of computers. In the winter of 1973-74, a coal miners' strike caused power cuts in Britain, preventing Dawkins from properly continuing his computer-driven research. He decided to write a book, which he finished a year later with "a tremendous momentum." The book was "The Selfish Gene," and its Preface starts, "This book should be read almost as though it were science fiction. It is designed to appeal to the imagination. But it is not science fiction: it is science."

When "The Selfish Gene" was published, in 1976, readers began writing to Dawkins that their lives had been changed; and most were pleased with the change. (Dawkins's peripheral theory of the self-replicating "meme," as a way of understanding the transmission of human culture and ideas -- a meme for religion, or for baseball hats worn backward -- began its impressive self-replicating career.) But Dawkins also caught the attention of his peers. Helena Crooning, a British philosopher of science, explains the response this way: "Very often in science one finds that there are ideas in the air, and lots of people hold them, but they don't even realize they hold them. The person who can crystallize them, and lay out not only the central idea but its implications for future scientific research can often make a tremendous contribution. And I think that's what 'The Selfish Gene' did. Lots of scientists, they'd been Darwinians all their lives, but they'd been inarticulate Darwinians. And now they really understood what was foundational to Darwinism and what was peripheral. And once you understand what is foundational, then you begin to deduce conclusions." In a variety of fields, Dawkins proved to be a catalyst.

In the twenty years following the publication of "The Selfish Gene" -- years of teaching, fatherhood, wealth, and encroaching responsibilities as the British media's favorite scientist -- Dawkins has published any number of papers and articles, and four more books, including "The Blind Watchmaker," a best-selling study of Darwinian design, written with the reach and elegance of "The Selfish Gene." On a rolling mass of ants in Panama, for instance:

I never did see the queen, but somewhere inside that boiling ball she was the central data bank, the repository of the master DNA of the whole colony. Those gasping soldiers were prepared to die for the queen, not because they loved their mother, not because they had been drilled in the ideals of patriotism, but simply because their brains and their jaws were built by genes stamped from the master die carried in the queen herself. They behaved like brave soldiers because they had inherited the genes of a long line of ancestral queens whose lives, and whose genes, had been saved by soldiers as brave as themselves. My soldiers had inherited the same genes from the present queen as those old soldiers had inherited from the ancestral queens. My soldiers were guarding the master copies of the very instructions that made them do the guarding. They were guarding the wisdom of their ancestors.

These have been twenty Years of rising confidence and influence. "The world must be full of people who are biologists today rather than physicists because of Dawkins," John Maynard Smith, the senior British biologist, says. Outside the universities, in a climate newly friendly to accessible science books, Dawkins has become a literary fixture. Ravi Mirchandani, who published Dawkins at Viking, says, "If you're an intelligent reader, and you read certain literary novels that everybody has to read, along with seeing Tarantino movies, then reading Richard Dawkins has become part of your cultural baggage."

Dawkins's version of evolution also attracts critics, for it is dazzlingly digital. It features "robots" and "vehicles" and DNA, not flesh and fur; some evolutionary biologists regard him as a kind of reductionist fanatic -- an "ultra-Darwinist" who overplays the smooth mathematical progress of natural selection and its relevance to an animal's every characteristic, every nook and cranny. A biting review of "The Selfish Gene" by Richard Lewontin, of Harvard, published in Nature, talked of "Dawkins's discovery of vulgar Darwinism." It was an error of "new Panglossians," Lewontin wrote, to think that "all describable behavior must be the direct product of natural selection." (This is the sin of excessive "adaptationism.") In the continuing debate, Maynard Smith, George Williams, and W. D. Hamilton are in one camp; in the other are Steven Rose, Lewontin, Leon Kamin (these three collaborated on a book called "Not in Our Genes"), and Stephen Jay Gould, the man who is in many ways Dawkins's American counterpart. Dawkins and Gould have undertaken the same project -- eliminating the barrier between the practice of science and its communication to a wider audience. And they stand shoulder to shoulder against the creationists. But they would not want to be stuck in the same elevator.

In 1979, Gould and Lewontin wrote a famous paper called "The Spandrels of San Marco and the Panglossian Paradigm: A Critique of the Adaptationist Programme," which argued that natural selection can be limited by or can be a by-product of an animal's architecture in the way that the spandrels of St. Mark's in Venice (described by the authors as "the tapering triangular spaces formed by the intersection of two rounded arches at right angles") are "necessary architectural by-products of mounting a dome on rounded arches," and were not designed to be painted upon, although that might be how it looks. Gould also contests the evolutionary "gradualism" of the Dawkins camp, and promotes "punctuated equilibrium" -- the theory that evolution goes by fits and starts. Gould's opponents suspect him of exaggerating his differences with contemporary Darwinism: they want him to know that one can make a stir in science without making a revolution. Dawkins said, "I really want to say that there are no major disagreements." But he added, "I think the tendency of American intellectuals to learn their evolution from him is unfortunate, and that's putting it mildly."

Earlier this year, Richard Dawkins took part in a public debate in a hall on the edge of Regent's Park, in central London. The debate, which was organized by the Oxford-based Jewish society L'Chaim, set Dawkins against the very distinguished Jewish scholar Rabbi Adin Steinsaltz. The question to be debated was "Does God exist?" In the lobby, tempers were fraying as it became clear that the event had been greatly oversubscribed. Three hundred people were sent away, and one could hear cries of "I've got a ticket! I'm not moving!" and so on

The two speakers took their places on the wooden stage of the main hall, and were introduced with some old Woody Allen jokes. Dawkins then spoke of design, and of the miserable logic of trying to use a God -- who must be complex -- as an explanation of the existence of complex things. By contrast, he said, "Darwinian evolution explains complicated things in terms of simple things." In reply, Rabbi Steinsaltz made an occasionally witty but rather digressive speech, in which he always seemed to lose interest in a point just before he made it. He talked of giraffs, though it was not entirely clear what we were to think of them. ("'You know these animals. Beautiful eyes.") Dawkins found himself arguing with a theist of his imagination rather than with the man to his right, who was frustratingly unresponsive to his favorite evolutionary sound bites. ("Not a single one of your ancestors died young. They all copulated at least once.") One member of the society told me that Dawkins was significantly gentler than he used to be at these meetings: he used to go into "a frenzy of savage attack, saying all religious people are delusional, weak-minded." That night, he seemed to win the debate, speaking in his curious shy, confident way.

This is the kind of event that presents the new Professor of Public Understanding with a problem: he has become wary of the atheist's reputation suffocating the evolutionist's. And yet he cares deeply about religion; he is sure that it matters. "It's important to recognize that religion isn't something sealed off in a watertight compartment," he says. "Religions do make claims about the universe -- the same kinds of claims that scientists make, except they're usually false." Richard Dawkins is not a great one for cultural relativism. He says, "The proof of the pudding is: When you actually fly to Your international conference of cultural anthropologists, do you go on a magic carpet or do you go on a Boeing 747?"

In Dawkins's kitchen in Oxford, a headline had been torn out of a newspaper and stuck on the wall, in an office-humor sort of way It read "THE PROBLEMS OF DAWKINISM." The main problem, which is experienced particularly by those who have not read his books, remains one of tone. Douglas Adams says, laughing, "Richard once made a rather wonderful remark to me. He said something like 'I really don't think I'm arrogant, but I do get impatient with people who don't share with me the same humility in front of the facts.'" The glory of Darwinism fills Dawkins's brain, but it drops out of the brains of others, or is nudged out by God or Freud or football or Uranus moving into Aquarius, and Dawkins finds this maddening. "It is almost as if the human brain were specifically designed to misunderstand Darwinism, and to find it hard to believe," he has written. Dawkins does not seem to have developed this point, and he sometimes allows disdain or mockery to take the place of a clearer understanding of it -- the evolution of resistance to evolution. Even the admiring Charles Simonyi, who funds the job for which Richard Dawkins is so precisely suited, and so precisely unsuited, says he has urged Dawkins to "tame his militancy."

"I'm a friendly enough sort of chap," Dawkins told me. "I'm not a hostile person to meet. But I think it's important to realize that when two opposite points of view are expressed with equal intensity, the truth does not necessarily lie exactly halfway between them. It is possible for one side to be simply wrong."

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Richard Dawkins: The man who knows the meaning of life

Richard Dawkins: The man who knows the meaning of life
He opened up the frontiers of science to a wide public and married one of Dr Who's assistants. But, as Colin Hughes finds, while banging the drum for his version of 'the truth' about evolution, he drowns out views that differ from his own.
Saturday October 3, 1998
People frequently ask Richard Dawkins: "Why do you bother getting up in the morning if the meaning of life boils down to such a cruel pitiless fact, that we exist merely to help replicate a string of molecules?" As he puts it: "They say to me, how can you bear to be alive if everything is so cold and empty and pointless? Well, at an academic level I think it is - but that doesn't mean you can live your life like that. One answer is that I feel privileged to be allowed to understand why the world exists, and why I exist, and I want to share it with other people." Dawkins' new book, Unweaving The Rainbow, to be published later this month, is billed as an attempt to answer the 'why get up?' question, and indeed the first couple of chapters do just that, arguing that scientific discovery has a compelling, almost poetic impact on the imagination.
"It's about why I think science is one of the supreme things that makes life worth living," he says. "We are fantastically privileged to exist at all, but then we also have the privilege of understanding this beautiful world in which we find ourselves. that should make us all the more eager to soak up as much as we possibly can of understanding our world and our place in it before we die."
Or, as the book puts it: "Mysteries do not lose their poetry when solved. Quite the contrary: the solution often turns out more beautiful than the puzzle... " In making this case Dawkins betrays all his rhetorical genius, and his faintly naive sense of everyday folk. He brilliantly berates those of us (all of us, probably) who succumb to the "anaesthetic of familiarity," by which he means allowing yourself to stop noticing that the world around you is coruscating with wonder. But he also shows how little he understands common humanity: "Just think," he enthuses, "instead of reading the football results you can read about distant galaxies!" As if one precludes the other.
When he expands in this way, hands clasped, leaning forward on a folding chair on the paved patio of his Oxford garden, he assumes a sparkling-eyed, boyish eagerness. This is his most appealing mode,

in which it is easy to warm to his articulate, infectious absorption in his life's work - explaining and elaborating the potent truth of evolutionary theory. But it is also clear that he is capable of a dry chill, of a wincing, suck-toothed disdain. So far from suffering fools, he is capable of pouring a withering stream of scorn on the kind of woolly thinkers and wet-minded pseudo-religious fantasists who form the large phalanx of his opponents.

In fact, most of the new book is less about how science provides a meaning to life than about how Dawkins himself finds purpose in the continuing battle for the supremacy of searing scientific truth.

Even when you're on his side, the tone sometimes feels unduly severe.

There lies the Dawkins paradox. Beginning with his 1976 book The Selfish Gene, which argues that life is simply a means of propagating DNA, with every creature ruthlessly determined to continue its own line, he has probably done more to focus lay intelligence on scientific truth in the past quarter century than any other individual, including Stephen Hawking, principally by writing with a compelling first-person directness. yet he is also capable of being peculiarly unengaging in person.

The man who writes and lectures so vividly that his images and ideas are indelibly printed on your mind, can be strangely remote. Why? Probably it's the combination of that maddening Oxford air of high intellectual superiority (in his case justified - he's a fellow of New College), attached to an acute personal sensitivity. However, people who know him say all this comes with a leavening of humour. John Krebs, head of the NERC and an old friend, says: "Some people see Richard as a relentlessly serious individual, without a lighter side. Actually he has a very well-developed sense of the ridiculous." He is one of those fortunate men in whom, despite catkin-white eyebrows and the greying hair of a 56-year-old, you can still see the face of his boyhood. He was born into a family of colonial forest officers, his grandfather in Burma, his father in Nyasaland - now Malawi - and then Kenya, which is where Clinton Richard was born in 1941, during the darkest days of the war. But if he modelled himself on any of them it was his uncle Colyear, a statistical biologist and fellow of St John's, Oxford, about whose lecturing Dawkins rhapsodizes: "I suppose I still subconsciously try to emulate his teaching style. He was quite stunning." When Richard was only seven his father unexpectedly inherited a farm near Chipping Norton and the family returned to England: not long after, Richard was sent to board at Oundle. Unusual among public schools at that time, Oundle had a self-consciously practical bent: boys were required to spend time making things in workshops.

You might expect in that atmosphere that Dawkins would storm at the natural sciences, replete with his family's long interest. In fact, he says, he felt no special enthusiasm at school for biology, and merely 'drifted' into that stream because of his family background. His biology teacher, Ioan Thomas, recalls: "He wasn't by any means a committed natural historian - it was rather a matter of wanting to be open-minded." The enthusiasm Dawkins really picked up at school was computing, and he recognises that his life-long fascination with programming has played a huge part in shaping his thought. The way computers think and operate is one of his dominant metaphors, and metaphor is his favourite tool.

The questioning mind was certainly there: according to Thomas, the boy was "alert and thoughtful enough" to realise that what he was learning in biology didn't tally with what he was being asked to imbibe at two compulsory Christian services every week. "I remember his housemaster ringing me up one Sunday evening, and I told him that 'requiring that young man to attend chapel every Sunday is doing him positive harm'." And though he didn't stand out as academically shining bright, he clearly had the determination to succeed: after A levels, preparing for Oxford entrance, Thomas told Dawkins' parents that their boy "might just scrape Oxford, but wasn't good enough to get into Balliol at this rate". Dawkins' 'rate' immediately shifted up a gear and he was accepted by Balliol. Even at Oxford, though, there is a sense that he slipped into studying zoology, rather than being captivated. But it was a lucky step since the subject of animal behaviour threw him directly into his preferred habitat of speculative debate as opposed to laboratory experiment. He has, as he puts it, done his "fair share" of hard observation and experiment in his time.

But it's not the sight of teeming tropical jungle life or the wonderful weirdness of observed creatures that really grips him: "What really fascinates me is that they are all - plants twining round the trees, ants on the jungle floor, extraordinary salamanders - in their immensely complicated, enmeshed ways doing the same fundamental thing, which is propagating genes. It's the joy of understanding that appeals to me." The crucial relationship at Oxford was with Niko Tinbergen, Dutch-born Nobel prize-winning ethologist, of whom Dawkins says he felt in awe: "He loved my essays, and said flattering things about them, and that encouraged me to do a DPhil, clearly a turning point in my life." One of Tinbergen's central contentions was that animal and plant bodies could be viewed as 'survival machines', an idea that played a key part in fertilising Dawkins' selfish gene metaphor. But his post-doctoral work set off in what he calls "mathematical directions" - actually constructing a model for interpreting decision-making in animals.

George Barlow, of the University of California, Berkeley, spotted Dawkins at an international ethological conference in Rennes in

1967. "I was stunned by the stellar performance of someone so new on the scene, and relatively unknown. He had the audience in the palm of his hand. His topic? A relatively esoteric problem of how best to determine the colour a chick preferred." The highlight, Barlow recalls, was Dawkins' demonstration of a little box chicken he had built, which electronically duplicated the way the chick distributed pecks. "He brought the house down. I figured if he could make such an abstract and potentially deadly dull question so fascinating, he was certainly going to make his mark." Barlow later that year offered him a job as an assistant professor. He tells how Dawkins, in his acceptance letter, pointed out tongue in cheek that his "great-great something or other was General Clinton who fought against the Americans in the War of Independence, and he hoped we could forgive him." Just before leaving for Berkeley Dawkins married for the first time, a researcher called Marian Stamp, so when they arrived in California (where the Barlows put them up initially) they were on honeymoon. Barlow recalls putting them in a corridor bedroom through which his daughters trooped at all hours: "Some honeymoon!" The young couple became close to Barlow's children: "It was Richard's first exposure to peanut butter and jelly sandwiches - he had the girls in stitches because he ate them with a knife and fork." Barlow's recollections also illustrate the kind of youthful intensity of the couple - how they set their clocks ahead an hour so that they would get up earlier and be more productive, and how Marian loaded Richard's razor with different blades in a blind experiment so that he could find out which brand was best without fear of bias. The picture is of a young, reserved man with a somewhat eccentric and slightly unworldly sense of humour, but also of phenomenal curiosity and intelligence, growing up in that late 1960s era of Buckminster Fuller radicalism and Vietnam protest.
When he first published The Selfish Gene its message was widely misunderstood to imply that human society is driven solely by the 'me' motive. Dawkins found himself interpreted far and wide as the intellectual apologist for self-seeking, anti-society Thatcherite economics. In fact his political instincts have always been on the liberal left: he worked for Eugene McCarthy's presidential campaign, and joined anti-war marches.
He came home from Berkeley to New College, Oxford, a hard-working, committed and quietly ambitious scientist. Dawkins resumed his connection with Tinbergen, along with his computational approach to ethology. But then a vengeful technician sabotaged the computer records where Dawkins worked, making it temporarily hard for his research to continue. Then the country was forced into a three-day working week: the consequent 1974 power cuts left Dawkins unable to keep up his lab work. He started using the free time to write a book about neo-Darwinist ideas which was eventually published as The

Selfish Gene.

Even now, re-reading it a quarter century on, the book's immediacy is still gripping. No wonder so many fellow scientists are sneeringly jealous of Dawkins' writing talent. It is bland and inadequate to say merely that he can express complex abstract ideas in easily comprehensible language. Dawkins is far more potent than your everyday populariser. The book's polemical spell is mesmeric: the prose compels not only your attention, but also your acceptance. It is little wonder that Selfish Gene changed the way people think. It even changed many lives.

Ever since, of course, the great debate in the scientific world has been over how original the ideas really were. Even at the time prominent supporters of Dawkins, such as John Maynard Smith and Bill Hamilton, said that Dawkins' drawing together of ideas - like those developed by the British geneticists RA Fisher and JBS Haldane, and the American, Sewall Wright, since the 1920s and 1930s - led to original strands of thought, even in the Selfish Gene itself. But there were vicious critics, notably the Harvard scientist Richard Lewontin who reviewed the book scathingly in Nature.

John Krebs says: "Richard has interpreted and explained the ideas of neo-Darwinism with unique clarity, force and elegance. He has also explored the consequences of extending these ideas into new domains. Often the creators of the core ideas will themselves read Richard's work and say, 'Gosh, I never thought of it in those terms', or 'I hadn't realised that one could deduce such and such from my starting point'." Professor Pat Bateson, provost of King's College, Cambridge, who has known Dawkins since their early twenties, has absolutely no doubt that his image for thinking about evolution really helped several generations of students and the lay public to think about evolution: "You can take any young biologist and they will say when they read Dawkins it all suddenly became clear. His extraordinary ability to use metaphors really brought the subject alive for people." But Bateson thinks any portrayal of Dawkins as "merely a populariser" is worse than cheap, it is actually wrong. "There are aspects of his thinking which go much deeper," he argues. The final chapter of Dawkins' book The Extended Phenotype contains what Bateson regards as a "very interesting and original" speculation about how development itself might have evolved - one of the trickier issues in evolution theory.

Michael Rodgers, who edited Selfish Gene and most of Dawkins' subsequent books, says while Dawkins has a sense of humour and a nice infectious laugh he is "an evangelist, and takes that side very seriously". After the book was published letters poured in from readers thanking Dawkins for opening their minds. Some told Rodgers that they had decided to study biology in consequence.

"One academic I talked to at the time criticised it for being too well written. Students, he said, would be seduced, ditch their critical faculties and believe it presented 'the truth'." The irony, of course, is that Dawkins frankly does regard his understanding of natural selection as the truth - a truth that is "beautiful in its power".

Rodgers says: "Thirty years ago there was in the UK a real anti-science feeling, and it was respectable to parade an ignorance of science. That's changed, and I think Richard can be credited in no small measure with helping to bring that about." Dawkins makes absolutely no attempt to claim a grand achievement for himself. "The image of the selfish gene enabled me to understand the ideas, and that helped other people understand it too. I was saying no more than RA Fisher said in 1930." The modesty is both beguiling and infuriating. Partly it's just the way Oxford dons are, always countering a speculative query with the apology that they don't really know enough about the subject, when in fact they are 100 times better placed to discuss it than you are. It's not as disconcerting, though, as his bristling discomfort with difficult personal questions, which leaves you feeling that he struggles to grasp how other people view him. He is sharply defensive about some areas of his private life - areas which probably say more about him than anything he has ever written or said about himself.

In his book Climbing Mount Improbable, Dawkins recalls how he asked his six-year-old daughter, Juliet, what flowers were for. She answered, not unreasonably given her age, that the purpose of flowers was to give us beautiful things to look at, and honey for the bees. Gently, her dad disabused her.

Since so much of the delight in reading Dawkins is his thrill at uncovering the elaborate wonders of the natural world (unravelling the byzantine relationships between figs and their co-dependent wasps, for instance), you wonder how having a child has affected him - perhaps enabling him to see the world through a child's eyes? After all, his Royal Institution Faraday lectures for children were a great success, captivating a young audience as expertly as a stage conjuror might.

Instead of leading him into reflections on children and childhood, the question makes Dawkins tense up and withdraw: "I don't see that much of her, to my enormous regret. I only see her alternate weekends. You're so busy trying to make sure the weekend is a success, and that things don't go badly wrong, you don't have the luxury of exploring those other things." Anyone who lives apart from their children can recognise those difficult feelings. And it is also clear that Dawkins adores his only daughter.

About Lalla Ward, his third wife, Dawkins talks very happily indeed. She is the pretty former Dr Who sidekick Romana, but he hastens to say that she played more serious parts too, such as Ophelia in the

BBC's Hamlet. They met at a party held by Douglas Adams, author of The Hitchhiker's Guide to the Galaxy (which Dawkins loves) and a former Dr Who scriptwriter ("apparently his scripts were a cut above the others", says Dawkins, loyally). Lalla has since drawn excellent sketches for Dawkins' books.

Their home is just off the Banbury Road, in one of those huge old north Oxford houses next to the university parks, that you approach by one of two gaps in a wall, scrunching over gravel through which bits of grass grow tastefully but not too tidily around the edges.

To the right of the front door is Dawkins' office, usually inhabited by his assistant Ingrid, and a neat cluster of desks, PCs, printers and fax machines (everything to do with Dawkins is orderly). To the left is a long sitting room decorated by an electric piano on one corner (for Juliet to practice on), and Lalla's famed collection of fairground carousel horses, inherited from her mother.

Straight through and you walk into a large garden that would naturally be described as 'country', except that you're within sprinting distance from Oxford city centre. There's an indoor pool on one flank of the paved patio, and a vast slab of Purbeck stone propped up as an outside table on the other. "It's the same stone as they used for those heads around the Sheldonian theatre," says Dawkins.

Life is obviously now very comfortable, presumably in part because of the endowment from Charles Simonyi, one of Bill Gates' Microsoft millionaires, who funded the chair of professor for the public understanding of science that Dawkins is the first to hold. The new job led him to write Unweaving the Rainbow. He felt obliged to lay out his credo, his reason for believing it important that non-specialists should have at least some grasp of what's known at the frontiers of science. But Dawkins carries so much baggage that it is impossible for him to write such a book without resuming the fierce diatribes against religion, or sardonic attacks on other evolutionists who he regards as misguided, which in great measure now define his public persona.

One of those battles is with Stephen Jay Gould, a warm and appealing American paleontologist who also writes with great panache about evolution, and whose books have hugely influenced both lay and scientific readers in the United States.

Many of Dawkins' friends think he should just let this argument lie, since, in their view, the difference is a relatively minor one centering on whether evolution occurred in a smooth and steady progression, or underwent periods of accelerated development interspersed with periods of comparative stagnation.

Dawkins accepts it is perfectly possible that evolutionary change moved faster at some times than others, but is driven to steely outrage by what he sees as the manipulation of fossil evidence to suggest that vast numbers of species sprang into existence in tiny periods of geological time.

Why does it bother Dawkins so much? Because, whereas many scientists are content for lay people merely to have a rough grasp of what's going on, Dawkins wants them to get it right. The truth matters. He cannot bear to see flabby writing (which is essentially what he accuses Gould of) lead people into a misunderstanding.

John Krebs says: "I think this is a lot of fuss about not very much. Although it is sometimes presented in the press as a fundamental disagreement about the role of Darwinism in evolution, I don't think it is anything of the sort. It is partly a matter of emphasis, and partly a matter of salesmen staking out their territories." But it matters to Dawkins because he fears that Gould gives people an excuse to doubt natural selection altogether: if species can suddenly spring into existence, perhaps God gave evolution a helping hand? No extrapolation could be better calculated to drive Dawkins into a fury of contention. At one point Dawkins said although Gould was a good writer "that makes him all the more damaging - people assume his ideas are scientific truths". Gould struck back: "It is not just a question of Dawkins' argument being inadequate. It's wrong." Many of Dawkins' friends worry that his militant atheism and evangelistic fervour damage not only his personal reputation, but also the scientific cause.

As Rodgers says: "Some academics, not necessarily believers, think it does harm to the public image of science when he suggests that science has, or will get, all the answers." But if that's what he passionately believes, surely that's what he should passionately say? George Barlow says that among the creationists of America (where some school boards came close to banning Darwinian textbooks), Dawkins is regarded as 'evil incarnate'. Dawkins talks more warily about religion now, which suggests that he has taken his friends' concern to heart. But it's more a question of his struggling (against his nature) to be more diplomatic in framing his argument. He hasn't changed his mind at all. In conversation, he emphasises how much he enjoys engaging with clerics on the issue of creation and natural selection, and makes it plain that the argument seems to him immensely important.

Asked if he finds believers actively objectionable, he says: "Not at all. In fact I find them interesting, because at least they're asking the right questions. They're just coming up with the wrong answer. What I can't understand is those people, particularly scientists, who say that you can put these matters into two separate compartments." The sharp logician in him won't allow a fellow scientist to believe two contradictory truths: he gave me a recent survey showing that scientists who believe in God are not only small in number but also dwindling, a discovery which hugely satisfies him.

If you were brave you'd speculate that middle age and his third wife have tempered Dawkins' demeanour. He delights in music, literature, all the normal pleasures of cultured humanity. The new book contains more personal reference than all his other books put together. But it also gives the strong impression that this intensely sensitive man is reacting to the long-standing criticism that he has only ever had one thing to say: after all, every book until now has been an elaboration on the The Selfish Gene's original theme. So now, at 57, he's exploring somewhere else.

But why should the criticism bother him? He may only ever have written about one question but of all questions it's arguably the biggest and the best - what are we, why are we here, where did we come from? Dawkins deeply believes he found the answer 30 years ago, and he wants you to know that it awes him still.

The only problem with this laudable ambition is that his talent does not really lie in winning people over with charm; it lies in cutting through comfortable illusions to expose the motiveless reality of life. And the plain fact is, some people cannot bear too much reality.

Unweaving The Rainbow is published by Penguin Press/Allen Lane on October 22, price £20.

Useful links
The Third Culture
When Religion Steps on Science's Turf by Richard Dawkins
Richard Dimbleby Lecture given by Richard Dawkins in 1996
The world of Richard Dawkins (unofficial website)

Interview with Richard DawkinsInterview with Richard Dawkins

Preliminaries

Between 13 August 1995 and 26 August 1995 Steven Carr posted the transcript of a 1994 Channel-4 (U.K.) interview with biologist Richard Dawkins to the Usenet newsgroup alt.atheism.moderated. With Steven's permission, I have made the postings available here. I have combined Steven's multiple postings into one document, made some formatting changes, deleted Steven's comments, fixed typos, and changed some British spellings to American ones.

In my opinion, Dawkins was as provocative and clear in his statements as ever, and I cannot but agree with what he says. Not surprisingly, the series of postings generated a mass of crackpot attempts at rationalizations of the concept of God with science and the Universe. In spite of the moderation, the signal-to-noise ratio in alt.atheism.moderated quickly plummeted to zero.

Feedback: If you have questions or comments regarding the HTML formatting, please send them to me at krishna_kunchith@hotmail.com. If you have any questions about the interview or transcription, direct them at Steven Carr. If you have comments about the contents of the interview, mail Richard Dawkins at Oxford.

Enjoy.

Krishna.

Introduction

Channel 4 in the UK ran a half-hour series of interviews in 1994 called The Vision Thing. Various people with different beliefs were interviewed by Sheena McDonald, a respected TV journalist. The only atheist viewpoint was put by Richard Dawkins on 15 Aug. 1994.

The views expressed do not necessarily agree with mine. This is not just the usual disclaimer.

Note that throughout the interview Sheena McDonald had a half-smile on her face as if to say "Well, these are strange opinions but I suppose I'll have to give them a hearing". She was though, as always, scrupulously fair.

At the time of the interview Richard Dawkins was reader in zoology at the University of Oxford. He is now Professor of Public Understanding of Science at Oxford. He currently has 3 of the top 10 best selling science books in Britain.

Steven Carr.

Interview: Sheena McDonald and Richard Dawkins

McDonald's intro: Imagine no religion! Even non-believers recognize the shock value of John Lennon's lyric. A godless universe is still a shocking idea in most parts of the world. But one English zoologist crusades for his vision of a world of truth, a world without religion, which he says is the enemy of truth, a world which understands the true meaning of life. He's called himself a scientific zealot. In London I met Richard Dawkins.

McDonald: Richard Dawkins, you have a vision of the world---this world free of lies, not the little lies that we protect ourselves with, but what you would see as the big lie, which is that God or some omnipotent creator made and oversees the world. Now, a lot of people are looking for meaning in the world, a lot of them find it through faith. So what's attractive about your godless world, what's beautiful---why would anyone want to live in your world?

Dawkins: The world and the universe is an extremely beautiful place, and the more we understand about it the more beautiful does it appear. It is an immensely exciting experience to be born in the world, born in the universe, and look around you and realize that before you die you have the opportunity of understanding an immense amount about that world and about that universe and about life and about why we're here. We have the opportunity of understanding far, far more than any of our predecessors ever. That is such an exciting possibility, it would be such a shame to blow it and end your life not having understood what there is to understand.

McDonald: Right, well, let's maximize this opportunity. Paint the world, describe the opportunity that too many of use---you will probably say most of us---are not exploiting to appreciate the world and to understand the world.

Dawkins: Well, suppose you look at an animal such as a human or a hedgehog or a bat, and you really want to understand how it works. The scientific way of understanding how it works would be to treat it rather as an engineer would treat a machine. So if an engineer was handed this television camera that engineer would get a screwdriver out, take it to bits, perhaps try to work out a circuit diagram and try to work out what this thing did, what it was good for, how it works, would explain the functioning of the whole machine in terms of the bits, in terms of the parts.

Then the engineer would probably want to know how it came to be where it was, what's the history of it---was it put together in a factory? Was it sort of suddenly just gelled together spontaneously? Now those are the sorts of questions that a scientist would ask about a bat or a hedgehog or a human, and we've got a long way to go, but a great deal of progress has been made. We really do understand a lot about how we and rats and pigeons work.

I've spoken only of the mechanism of a living thing. There's a whole other set of questions about the history of living things, because each living thing comes into the world through being born or hatched, so you have to ask, where did it get its structure from? It got it largely from its genes. Where do the genes come from? From the parents, the grand-parents, the great-grand parents. You go on back through the history, back through countless generations of history, through fish ancestors, through worm-like ancestors, through protozoa-like ancestors, to bacteria-like ancestors.

McDonald: But the end point of this process would simply be an understanding of the physical world.

Dawkins: What else is there?

McDonald: But to accept your vision, one has to reject what many people hold very dear and close, which is faith. Now, why is faith, why is religious faith incompatible with your vision?
Dawkins: Well, faith as I understand it---you wouldn't bother to use the word faith unless it was being contrasted with some other means of knowing something. So faith to me means knowing something just because you know it's true, rather than because you have seen any evidence that it's true.
McDonald: But if I say I believe in God, you cannot disprove the existence of God.
Dawkins: No, and the virtue of using evidence is precisely that we can come to an agreement about it. But if you listen to two people who are arguing about something, and they each of them have passionate faith that they're right, but they believe different things---they belong to different religions, different faiths, there is nothing they can do to settle their disagreement short of shooting each other, which is what they very often actually do.
McDonald: If religion is an obstacle to understanding what you're saying, why is it getting it wrong?
Dawkins: A creator who created the universe or set up the laws of physics so that life would evolve or who actually supervised the evolution of life, or anything like that, would have to be some sort of super-intelligence, some sort of mega-mind. That mega-mind would have had to be present right at the start of the universe. The whole message of evolution is that complexity and intelligence and all the things that would go with being a creative force come late, they come as a consequence of hundreds of millions of years of natural selection. There was no intelligence early on in the universe. Intelligence arose, it's arisen here, maybe it's arisen on lots of other places in the universe. Maybe somewhere in some other galaxy there is a super-intelligence so colossal that from our point of view it would be a god. But it cannot have been the sort of God that we need to explain the origin of the universe, because it cannot have been there that early.
McDonald: So religion is peddling a fundamental untruth.
Dawkins: Well, I think it is yes.
McDonald: And there is no possibility of there being something beyond our knowing, beyond your ability as a scientist, zoologist, to [...]
Dawkins: No, that's quite different. I think there's every possibility that there might be something beyond our knowing. All I've said is that I don't think there is any intelligence or any creativity or any purposiveness before the first few hundred million years that the universe has been in existence. So I don't think it's helpful to equate that which we don't understand with God in any sense that is already understood in the existing religions.
The gods that are already understood in existing religions are all thoroughly documented. They do things like forgive sins and impregnate virgins, and they do all sorts of rather ordinary, mundane, human kinds of things. That has nothing whatever to do with the high-flown profound difficulties that science may yet face in understanding the deep problems of the universe.
McDonald: Now a lot of people find great comfort from religion. Not everybody is

as you are---well-favored, handsome, wealthy, with a good job, happy family life. I mean, your life is good---not everybody's life is good, and religion brings them comfort.
Dawkins: There are all sorts of things that would be comforting. I expect an injection of morphine would be comforting---it might be more comforting, for all I know. But to say that something is comforting is not to say that it's true.
McDonald: You have rejected religion, and you have written about and posited your own answers to the fundamental questions of life, which are---very crudely, that we and hedgehogs and bats and trees and geckos are driven by genetic and non-genetic replicators. Now instantly I want to know, what does that mean?
Dawkins: Replicators are things that have copies of themselves made. It's a very, very powerful---its' hard to realize what a powerful thing it was when the first self-replicating entity came into the world. Nowadays the most important self-replicating entities we know are DNA molecules; the original ones probably weren't DNA molecules, but they did something similar. Once you've got self-replicating entities---things that make copies of themselves---you get a population of them.
McDonald: In that very raw description that makes us---what makes us us? We're no more than collections of inherited genes each fighting to make its way by the survival of the fittest.
Dawkins: Yes, if you ask me as a poet to say, how do I react to the idea of being a vehicle for DNA? It doesn't sound very romantic, does it? It doesn't sound the sort of vision of life that a poet would have; and I'm quite happy, quite ready to admit that when I'm not thinking about science I'm thinking in a very different way.
It is a very helpful insight to say we are vehicles for our DNA, we are hosts for DNA parasites which are our genes. Those are insights which help us to understand an aspect of life. But it's emotive to say, that's all there is to it, we might as well give up going to Shakespeare plays and give up listening to music and things, because that's got nothing to do with it. That's an entirely different subject.
McDonald: Let's talk about listening to music and going to Shakespeare plays. Now, you coined a word to describe all these various activities which are not genetically driven, and that word is 'meme' and again this is a replicating process.
Dawkins: Yes, there are cultural entities which replicate in something like the same way as DNA does. The spread of the habit of wearing a baseball hat backwards is something that has spread around the Western world like an epidemic. It's like a smallpox epidemic. You could actually do epidemiology on the reverse baseball hat. It rises to a peak, plateaus and I sincerely hope it will die down soon.
McDonald: What about voting Labour?
Dawkins: Well, you can make---one can take more serious things like that. In a way, I'd rather not get into that, because I think there are better reasons for voting Labour than just slavish imitation of what other people do. Wearing a reverse baseball hat---as far as I know, there is no good reason for that.

One does it because one sees one's friends do or, and one thinks it looks cool, and that's all. So that really is like a measles epidemic, it really does spread from brain to brain like a virus.
McDonald: So voting intentions you wouldn't put into that bracket. What about religious practices?
Dawkins: Well, that's a better example. It doesn't spread, on the whole, in a horizontal way, like a measles epidemic. It spreads in a vertical way down the generations. But that kind of thing, I think, spreads down the generations because children at a certain age are very vulnerable to suggestion.
They tend to believe what they're told, and there are very good reasons for that. It is easy to see in a Darwinian explanation why children should be equipped with brains that believe what adults tell them. After all, they have to learn a language, and learn a lot else from adults. Why wouldn't they believe it if they're told that they have to pray in a certain way? But in particular---let's just rephrase that---if they're told that not only do they have to behave in such a way, but when they grow up it is their duty to pass on the same message to their children.
Now, once you've got that little recipe, that really is a recipe for passing on and on down the generations. It doesn't matter how silly the original instruction is, if you tell it with sufficient conviction to sufficiently young and gullible children such that when they grow up they will pass it on to their children, then it will pass on and it will pass on and it will spread and that could be sufficient explanation.
McDonald: But religion is a very successful meme. I mean, in your own structures the genes that survive---the ones with the most selfish and successful genes presumably have some merit. Now if religion is a meme which has survived over thousands and thousands of years, is it not possible that there is some intrinsic merit in that?
Dawkins: Yes, there is merit in it. If you ask the question, why does any replicating entity survive over the years and the generations, it is because it has merit. But merit to a replicator just means that it's good at replicating.
The rabies virus has considerable merit, and the AIDS virus has enormous merit. These things spread very successfully, and natural selection has built into them extremely effective methods of spreading. In the case of the rabies virus it causes its victims to foam at the mouth, and the virus is actually spread in saliva. It causes them to bite and to become aggressive, so they tend to bite other animals, and the saliva gets into them and it gets passed on. This is a very, very successful virus. It has very considerable merit.
In a way the whole message of the meme and gene idea is that merit is defined as goodness at getting itself spread around, goodness at self-replication. That's of course very different from merit as we humans might judge it.
McDonald: You've chosen an analogy there for religion which a lot of them would find rather hurtful---that it's like an AIDS virus, like a rabies virus.
Dawkins: I think it's a very good analogy. I'm sorry if it's hurtful. I'm trying to explain why these things spread; and I think it's like a chain letter. It is the same kind of stick and carrot. It's not, probably, deliberately thought out.

I could write on a piece of paper "Make two copies of this paper and pass them to friends". I could give it to you. You would read it and make two copies and pass them, and they would make 2 copies and it becomes 4 copies, 8, 16 copies. Pretty soon the whole world would be knee-deep in paper. But of course there has to be some sort of inducement, so I would have to add something like this "If you do not make 2 copies of this bit of paper and pass it on, you will have bad luck, or you will go to hell, or some dreadful misfortune will befall you".
I think if we start with a chain letter and then say, well, the chain letter principle is too simple in itself, but if we then sort of build upon the chain letter principle and look upon more and more sophisticated inducements to pass on the message, we shall have a successful explanation.
McDonald: But that's all it can be, I mean, sophisticated inducements or threats. I was only bothered that a successful meme may invoke something which has not yet been found in your universe by your methods.
Dawkins: The sophisticated inducements can include the B Minor Mass and the St. Matthew Passion. I mean, they're pretty good stuff. They're very sophisticated and very, very beautiful---stained glass windows, Chartres Cathedral, they work and no wonder they work. I mean they're beautifully done, beautifully crafted. But I think what you're asking is, does the success of religion down the centuries imply that there must be some truth in its claims? I don't think that is necessary at all, because I think there are plenty of other good explanations which do a better job.
McDonald: Does it exasperate you that people find more pleasure and inspiration in Chartres or Beethoven or indeed great mosques than they do in the anatomy of a lizard?
Dawkins: No, not at all. I mean, I think that great artistic experiences---I don't want to downplay them in any way. I think they are very, very great experiences, and scientific understanding is on a par with them.
McDonald: And yet, these great artistic achievements have been impelled by untruths.
Dawkins: Just think how much greater they would have been if they had been impelled by truth.
McDonald: But can the anatomy of a lizard provoke a great choral symphony?
Dawkins: By calling it the anatomy of a lizard, you, as it were, play for laughs. But if you put it another way---let's say, does geological time or does the evolution of life on earth, could that be the inspiration for a great symphony? Well, of course, it could. It would be hard to imagine a more colossal inspiration for a great piece of music or poetry than 2,000 million years of slow, gradual evolutionary change.
McDonald: But ultimately, there's no point beyond the personal celebration of each life, as far as you're able to. We hope that we're not born into a famine queue in central Africa. But that's not sufficient for people. Maybe they want [...]
Dawkins: Look, it may not be [...]
McDonald: But tough, you say [...]

Dawkins:Tough, yes. I don't want to sound callous. I mean, even if I have nothing to offer, that doesn't matter, because that still doesn't mean that what anybody else has to offer therefore has to be true.
McDonald: Indeed, but you care about it.
Dawkins: Yes, I do want to offer something. I just wanted to give as a preamble the point that there may be a vacuum which is left. If religion goes, there may well be a vacuum in important ways in people's psychology, in people's happiness, and I don't claim to be able to fill that vacuum, and that is not what I want to claim to be able to do. I want to find out what's true.
Now, as for what I might have to offer, I've tried to convey the excitement, the exhilaration of getting as complete a picture of the world and the universe in which you live as possible. You have the power to make a pretty good model of the universe in which you live. It's going to be temporary, you're going to die, but it would be the best way you could spend your time in the universe, to understand why you're there and place as accurate model of the universe as you can inside your head. That's what I would like to encourage people to try to do. I think it's an immensely fulfilling thing to do.
McDonald: And that will be a better world?
Dawkins: It will certainly be a truer world. I mean, people would have a truer view of the world. I think it would probably be a better world. I think people would be less ready to fight each other because so much of the motivation for fighting would have been removed. I think it would be a better world. It would be a better world in the sense that people would be more fulfilled in having a proper understanding of the world instead of a superstitious understanding.
McDonald: So here we are, in your truer world---except we're not, because for the reasons of juvenile gullibility you suggested the religion meme will continue to replicate itself around the world. For ever will it, or will we ever come to your world?
Dawkins: I suspect for a very long time. I don't know about for ever, whatever for ever is. I mean, I think religion has got an awful long time to go yet, certainly in some parts of the world. I find that a rather depressing prospect, but it is probably true.
McDonald: Isn't that to an extent because you've said yourself, what you have to say may not fill the vacuum which would be left if religion were discarded?
Dawkins: I feel no vacuum. I mean, I feel very happy, very fulfilled. I love my life and I love all sorts of aspects of it which have nothing to do with my science. So I don't have a vacuum. I don't feel cold and bleak. I don't think the world is a cold and bleak place. I think the world is a lovely and a friendly place and I enjoy being in it.
McDonald: Do you think about death?
Dawkins: Yes. I mean, it's something which is going to happen to all of us and [...]
McDonald: How do you prepare for death in a world where there isn't a god?
Dawkins: You prepare for it by facing up to the truth, which is that life is what we have and so we had better live our life to the full while we have it, because there is nothing after it. We are very lucky accidents or at least each

one of us is---if we hadn't been here, someone else would have been. I take all this to reinforce my view that I am fantastically lucky to be here and so are you, and we ought to use our brief time in the sunlight to maximum effect by trying to understand things and get as full a vision of the world and life as our brains allow us to, which is pretty full.

McDonald: And that is the first duty, right, responsibility, pleasure of man and woman. Christians would say "love God, love your neighbor". You would say "try to understand".

Dawkins: Well, I wouldn't wish to downplay love your neighbor. It would be rather sad if we didn't do that. But, having agreed that we should love our neighbor and all the other things that are embraced by that wee phrase, I think that, yes, understand, understand is a pretty good commandment.

(End of interview)

Sheena McDonald's wrap-up to camera: Richard Dawkins celebrates life before death with infectious enthusiasm. He rejects life after death with---for many---uncomfortable enthusiasm. In doing so he shows the courage of a true zealot, to go on preaching in the face of continuing resistance to a godless universe. It remains to be seen whether the Dawkins meme, his vision of truth, will replicate with the success that the prophets, priests, popes and gurus have enjoyed.

[Miscellaneous | Krishna Kunchithapadam]

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Interview with Richard Dawkins

Preliminaries

Between 13 August 1995 and 26 August 1995 Steven Carr posted the transcript of a 1994 Channel-4 (U.K.) interview with biologist Richard Dawkins to the Usenet newsgroup alt.atheism.moderated. With Steven's permission, I have made the postings available here. I have combined Steven's multiple postings into one document, made some formatting changes, deleted Steven's comments, fixed typos, and changed some British spellings to American ones.

In my opinion, Dawkins was as provocative and clear in his statements as ever, and I cannot but agree with what he says. Not surprisingly, the series of postings generated a mass of crackpot attempts at rationalizations of the concept of God with science and the Universe. In spite of the moderation, the signal-to-noise ratio in alt.atheism.moderated quickly plummeted to zero.

Feedback: If you have questions or comments regarding the HTML formatting, please send them to me at krishna_kunchith@hotmail.com. If you have any questions about the interview or transcription, direct them at Steven Carr. If you have comments about the contents of the interview, mail Richard Dawkins at Oxford.

Enjoy.

Krishna.

Introduction

Channel 4 in the UK ran a half-hour series of interviews in 1994 called The Vision Thing. Various people with different beliefs were interviewed by Sheena McDonald, a respected TV journalist. The only atheist viewpoint was put by Richard Dawkins on 15 Aug. 1994.

The views expressed do not necessarily agree with mine. This is not just the usual disclaimer.

Note that throughout the interview Sheena McDonald had a half-smile on her face as if to say "Well, these are strange opinions but I suppose I'll have to give them a hearing". She was though, as always, scrupulously fair.

At the time of the interview Richard Dawkins was reader in zoology at the University of Oxford. He is now Professor of Public Understanding of Science at Oxford. He currently has 3 of the top 10 best selling science books in Britain.

Steven Carr.

Interview: Sheena McDonald and Richard Dawkins

McDonald's intro: Imagine no religion! Even non-believers recognize the shock value of John Lennon's lyric. A godless universe is still a shocking idea in most parts of the world. But one English zoologist crusades for his vision of a world of truth, a world without religion, which he says is the enemy of truth, a world which understands the true meaning of life. He's called himself a scientific zealot. In London I met Richard Dawkins.

McDonald: Richard Dawkins, you have a vision of the world---this world free of lies, not the little lies that we protect ourselves with, but what you would see as the big lie, which is that God or some omnipotent creator made and oversees the world. Now, a lot of people are looking for meaning in the world, a lot of them find it through faith. So what's attractive about your godless world, what's beautiful---why would anyone want to live in your world?

Dawkins: The world and the universe is an extremely beautiful place, and the more we understand about it the more beautiful does it appear. It is an immensely exciting experience to be born in the world, born in the universe, and

look around you and realize that before you die you have the opportunity of understanding an immense amount about that world and about that universe and about life and about why we're here. We have the opportunity of understanding far, far more than any of our predecessors ever. That is such an exciting possibility, it would be such a shame to blow it and end your life not having understood what there is to understand.

McDonald: Right, well, let's maximize this opportunity. Paint the world, describe the opportunity that too many of us---you will probably say most of us---are not exploiting to appreciate the world and to understand the world.

Dawkins: Well, suppose you look at an animal such as a human or a hedgehog or a bat, and you really want to understand how it works. The scientific way of understanding how it works would be to treat it rather as an engineer would treat a machine. So if an engineer was handed this television camera that engineer would get a screwdriver out, take it to bits, perhaps try to work out a circuit diagram and try to work out what this thing did, what it was good for, how it works, would explain the functioning of the whole machine in terms of the bits, in terms of the parts.

Then the engineer would probably want to know how it came to be where it was, what's the history of it---was it put together in a factory? Was it sort of suddenly just gelled together spontaneously? Now those are the sorts of questions that a scientist would ask about a bat or a hedgehog or a human, and we've got a long way to go, but a great deal of progress has been made. We really do understand a lot about how we and rats and pigeons work.

I've spoken only of the mechanism of a living thing. There's a whole other set of questions about the history of living things, because each living thing comes into the world through being born or hatched, so you have to ask, where did it get its structure from? It got it largely from its genes. Where do the genes come from? From the parents, the grand-parents, the great-grand parents. You go on back through the history, back through countless generations of history, through fish ancestors, through worm-like ancestors, through protozoa-like ancestors, to bacteria-like ancestors.

McDonald: But the end point of this process would simply be an understanding of the physical world.

Dawkins: What else is there?

McDonald: But to accept your vision, one has to reject what many people hold very dear and close, which is faith. Now, why is faith, why is religious faith incompatible with your vision?

Dawkins: Well, faith as I understand it---you wouldn't bother to use the word faith unless it was being contrasted with some other means of knowing something. So faith to me means knowing something just because you know it's true, rather than because you have seen any evidence that it's true.

McDonald: But if I say I believe in God, you cannot disprove the existence of God.

Dawkins: No, and the virtue of using evidence is precisely that we can come to an agreement about it. But if you listen to two people who are arguing about something, and they each of them have passionate faith that they're right, but they believe different things---they belong to different religions, different faiths, there is nothing they can do to settle their disagreement short of shooting each other, which is what they very often actually do.

McDonald: If religion is an obstacle to understanding what you're saying, why is it getting it wrong?

Dawkins: A creator who created the universe or set up the laws of physics so that life would evolve or who actually supervised the evolution of life, or anything like that, would have to be some sort of super-intelligence, some sort of mega-mind. That mega-mind would have had to be present right at the start of the universe. The whole message of evolution is that complexity and intelligence and all the things that would go with being a creative force come late, they come as a consequence of hundreds of millions of years of natural selection. There was no intelligence early on in the universe. Intelligence arose, it's

arisen here, maybe it's arisen on lots of other places in the universe. Maybe somewhere in some other galaxy there is a super-intelligence so colossal that from our point of view it would be a god. But it cannot have been the sort of God that we need to explain the origin of the universe, because it cannot have been there that early.

McDonald: So religion is peddling a fundamental untruth.

Dawkins: Well, I think it is yes.

McDonald: And there is no possibility of there being something beyond our knowing, beyond your ability as a scientist, zoologist, to [...]

Dawkins: No, that's quite different. I think there's every possibility that there might be something beyond our knowing. All I've said is that I don't think there is any intelligence or any creativity or any purposiveness before the first few hundred million years that the universe has been in existence. So I don't think it's helpful to equate that which we don't understand with God in any sense that is already understood in the existing religions.

The gods that are already understood in existing religions are all thoroughly documented. They do things like forgive sins and impregnate virgins, and they do all sorts of rather ordinary, mundane, human kinds of things. That has nothing whatever to do with the high-flown profound difficulties that science may yet face in understanding the deep problems of the universe.

McDonald: Now a lot of people find great comfort from religion. Not everybody is as you are---well-favored, handsome, wealthy, with a good job, happy family life. I mean, your life is good---not everybody's life is good, and religion brings them comfort.

Dawkins: There are all sorts of things that would be comforting. I expect an injection of morphine would be comforting---it might be more comforting, for all I know. But to say that something is comforting is not to say that it's true.

McDonald: You have rejected religion, and you have written about and posited your own answers to the fundamental questions of life, which are---very crudely, that we and hedgehogs and bats and trees and geckos are driven by genetic and non-genetic replicators. Now instantly I want to know, what does that mean?

Dawkins: Replicators are things that have copies of themselves made. It's a very, very powerful---its' hard to realize what a powerful thing it was when the first self-replicating entity came into the world. Nowadays the most important self-replicating entities we know are DNA molecules; the original ones probably weren't DNA molecules, but they did something similar. Once you've got self-replicating entities---things that make copies of themselves---you get a population of them.

McDonald: In that very raw description that makes us---what makes us us? We're no more than collections of inherited genes each fighting to make its way by the survival of the fittest.

Dawkins: Yes, if you ask me as a poet to say, how do I react to the idea of being a vehicle for DNA? It doesn't sound very romantic, does it? It doesn't sound the sort of vision of life that a poet would have; and I'm quite happy, quite ready to admit that when I'm not thinking about science I'm thinking in a very different way.

It is a very helpful insight to say we are vehicles for our DNA, we are hosts for DNA parasites which are our genes. Those are insights which help us to understand an aspect of life. But it's emotive to say, that's all there is to it, we might as well give up going to Shakespeare plays and give up listening to music and things, because that's got nothing to do with it. That's an entirely different subject.

McDonald: Let's talk about listening to music and going to Shakespeare plays. Now, you coined a word to describe all these various activities which are not genetically driven, and that word is 'meme' and again this is a replicating process.

Dawkins: Yes, there are cultural entities which replicate in something like the same way as DNA does. The spread of the habit of wearing a baseball hat backwards is something that has spread around the Western world like an

epidemic. It's like a smallpox epidemic. You could actually do epidemiology on the reverse baseball hat. It rises to a peak, plateaus and I sincerely hope it will die down soon.
McDonald: What about voting Labour?
Dawkins: Well, you can make---one can take more serious things like that. In a way, I'd rather not get into that, because I think there are better reasons for voting Labour than just slavish imitation of what other people do. Wearing a reverse baseball hat---as far as I know, there is no good reason for that.
One does it because one sees one's friends do or, and one thinks it looks cool, and that's all. So that really is like a measles epidemic, it really does spread from brain to brain like a virus.
McDonald: So voting intentions you wouldn't put into that bracket. What about religious practices?
Dawkins: Well, that's a better example. It doesn't spread, on the whole, in a horizontal way, like a measles epidemic. It spreads in a vertical way down the generations. But that kind of thing, I think, spreads down the generations because children at a certain age are very vulnerable to suggestion.
They tend to believe what they're told, and there are very good reasons for that. It is easy to see in a Darwinian explanation why children should be equipped with brains that believe what adults tell them. After all, they have to learn a language, and learn a lot else from adults. Why wouldn't they believe it if they're told that they have to pray in a certain way? But in particular---let's just rephrase that---if they're told that not only do they have to behave in such a way, but when they grow up it is their duty to pass on the same message to their children.
Now, once you've got that little recipe, that really is a recipe for passing on and on down the generations. It doesn't matter how silly the original instruction is, if you tell it with sufficient conviction to sufficiently young and gullible children such that when they grow up they will pass it on to their children, then it will pass on and it will pass on and it will spread and that could be sufficient explanation.
McDonald: But religion is a very successful meme. I mean, in your own structures the genes that survive---the ones with the most selfish and successful genes presumably have some merit. Now if religion is a meme which has survived over thousands and thousands of years, is it not possible that there is some intrinsic merit in that?
Dawkins: Yes, there is merit in it. If you ask the question, why does any replicating entity survive over the years and the generations, it is because it has merit. But merit to a replicator just means that it's good at replicating.
The rabies virus has considerable merit, and the AIDS virus has enormous merit. These things spread very successfully, and natural selection has built into them extremely effective methods of spreading. In the case of the rabies virus it causes its victims to foam at the mouth, and the virus is actually spread in saliva. It causes them to bite and to become aggressive, so they tend to bite other animals, and the saliva gets into them and it gets passed on. This is a very, very successful virus. It has very considerable merit.
In a way the whole message of the meme and gene idea is that merit is defined as goodness at getting itself spread around, goodness at self-replication. That's of course very different from merit as we humans might judge it.
McDonald: You've chosen an analogy there for religion which a lot of them would find rather hurtful---that it's like an AIDS virus, like a rabies virus.
Dawkins: I think it's a very good analogy. I'm sorry if it's hurtful. I'm trying to explain why these things spread; and I think it's like a chain letter. It is the same kind of stick and carrot. It's not, probably, deliberately thought out.

I could write on a piece of paper "Make two copies of this paper and pass them to friends". I could give it to you. You would read it and make two copies and pass them, and they would make 2 copies and it becomes 4 copies, 8, 16 copies. Pretty soon the whole world would be knee-deep in paper. But of course there has

to be some sort of inducement, so I would have to add something like this "If you do not make 2 copies of this bit of paper and pass it on, you will have bad luck, or you will go to hell, or some dreadful misfortune will befall you".
I think if we start with a chain letter and then say, well, the chain letter principle is too simple in itself, but if we then sort of build upon the chain letter principle and look upon more and more sophisticated inducements to pass on the message, we shall have a successful explanation.
McDonald: But that's all it can be, I mean, sophisticated inducements or threats. I was only bothered that a successful meme may invoke something which has not yet been found in your universe by your methods.
Dawkins: The sophisticated inducements can include the B Minor Mass and the St. Matthew Passion. I mean, they're pretty good stuff. They're very sophisticated and very, very beautiful---stained glass windows, Chartres Cathedral, they work and no wonder they work. I mean they're beautifully done, beautifully crafted.
But I think what you're asking is, does the success of religion down the centuries imply that there must be some truth in its claims? I don't think that is necessary at all, because I think there are plenty of other good explanations which do a better job.
McDonald: Does it exasperate you that people find more pleasure and inspiration in Chartres or Beethoven or indeed great mosques than they do in the anatomy of a lizard?
Dawkins: No, not at all. I mean, I think that great artistic experiences---I don't want to downplay them in any way. I think they are very, very great experiences, and scientific understanding is on a par with them.
McDonald: And yet, these great artistic achievements have been impelled by untruths.
Dawkins: Just think how much greater they would have been if they had been impelled by truth.
McDonald: But can the anatomy of a lizard provoke a great choral symphony?
Dawkins: By calling it the anatomy of a lizard, you, as it were, play for laughs. But if you put it another way---let's say, does geological time or does the evolution of life on earth, could that be the inspiration for a great symphony? Well, of course, it could. It would be hard to imagine a more colossal inspiration for a great piece of music or poetry than 2,000 million years of slow, gradual evolutionary change.
McDonald: But ultimately, there's no point beyond the personal celebration of each life, as far as you're able to. We hope that we're not born into a famine queue in central Africa. But that's not sufficient for people. Maybe they want [...]
Dawkins: Look, it may not be [...]
McDonald: But tough, you say [...]
Dawkins:Tough, yes. I don't want to sound callous. I mean, even if I have nothing to offer, that doesn't matter, because that still doesn't mean that what anybody else has to offer therefore has to be true.
McDonald: Indeed, but you care about it.
Dawkins: Yes, I do want to offer something. I just wanted to give as a preamble the point that there may be a vacuum which is left. If religion goes, there may well be a vacuum in important ways in people's psychology, in people's happiness, and I don't claim to be able to fill that vacuum, and that is not what I want to claim to be able to do. I want to find out what's true.
Now, as for what I might have to offer, I've tried to convey the excitement, the exhilaration of getting as complete a picture of the world and the universe in which you live as possible. You have the power to make a pretty good model of the universe in which you live. It's going to be temporary, you're going to die, but it would be the best way you could spend your time in the universe, to understand why you're there and place as accurate model of the universe as you can inside your head. That's what I would like to encourage people to try to do.
I think it's an immensely fulfilling thing to do.
McDonald: And that will be a better world?

Dawkins: It will certainly be a truer world. I mean, people would have a truer view of the world. I think it would probably be a better world. I think people would be less ready to fight each other because so much of the motivation for fighting would have been removed. I think it would be a better world. It would be a better world in the sense that people would be more fulfilled in having a proper understanding of the world instead of a superstitious understanding.
McDonald: So here we are, in your truer world---except we're not, because for the reasons of juvenile gullibility you suggested the religion meme will continue to replicate itself around the world. For ever will it, or will we ever come to your world?
Dawkins: I suspect for a very long time. I don't know about for ever, whatever for ever is. I mean, I think religion has got an awful long time to go yet, certainly in some parts of the world. I find that a rather depressing prospect, but it is probably true.
McDonald: Isn't that to an extent because you've said yourself, what you have to say may not fill the vacuum which would be left if religion were discarded?
Dawkins: I feel no vacuum. I mean, I feel very happy, very fulfilled. I love my life and I love all sorts of aspects of it which have nothing to do with my science. So I don't have a vacuum. I don't feel cold and bleak. I don't think the world is a cold and bleak place. I think the world is a lovely and a friendly place and I enjoy being in it.
McDonald: Do you think about death?
Dawkins: Yes. I mean, it's something which is going to happen to all of us and [...]
McDonald: How do you prepare for death in a world where there isn't a god?
Dawkins: You prepare for it by facing up to the truth, which is that life is what we have and so we had better live our life to the full while we have it, because there is nothing after it. We are very lucky accidents or at least each one of us is---if we hadn't been here, someone else would have been. I take all this to reinforce my view that I am fantastically lucky to be here and so are you, and we ought to use our brief time in the sunlight to maximum effect by trying to understand things and get as full a vision of the world and life as our brains allow us to, which is pretty full.
McDonald: And that is the first duty, right, responsibility, pleasure of man and woman. Christians would say "love God, love your neighbor". You would say "try to understand".
Dawkins: Well, I wouldn't wish to downplay love your neighbor. It would be rather sad if we didn't do that. But, having agreed that we should love our neighbor and all the other things that are embraced by that wee phrase, I think that, yes, understand, understand is a pretty good commandment.

(End of interview)

Sheena McDonald's wrap-up to camera: Richard Dawkins celebrates life before death with infectious enthusiasm. He rejects life after death with---for many---uncomfortable enthusiasm. In doing so he shows the courage of a true zealot, to go on preaching in the face of continuing resistance to a godless universe. It remains to be seen whether the Dawkins meme, his vision of truth, will replicate with the success that the prophets, priests, popes and gurus have enjoyed.

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The Improbability of God

by Richard Dawkins

The following article is from Free Inquiry MagazineVolume 18, Number 3.

Much of what people do is done in the name of God. Irishmen blow each other up in his name. Arabs blow themselves up in his name. Imams and ayatollahs oppress women in his name. Celibate popes and priests mess up people's sex lives in his name. Jewish *shohets* cut live animals' throats in his name. The achievements of religion in past history - bloody crusades, torturing inquisitions, mass-murdering conquistadors, culture-destroying missionaries, legally enforced resistance to each new piece of scientific truth until the last possible moment - are even more impressive. And what has it all been in aid of? I believe it is becoming increasingly clear that the answer is absolutely nothing at all. There is no reason for believing that any sort of gods exist and quite good reason for believing that they do not exist and never have. It has all been a gigantic waste of time and a waste of life. It would be a joke of cosmic proportions if it weren't so tragic.

Why do people believe in God? For most people the answer is still some version of the ancient Argument from Design. We look about us at the beauty and intricacy of the world - at the aerodynamic sweep of a swallow's wing, at the delicacy of flowers and of the butterflies that fertilize them, through a microscope at the teeming life in every drop of pond water, through a telescope at the crown of a giant redwood tree. We reflect on the electronic complexity and optical perfection of our own eyes that do the looking. If we have any imagination, these things drive us to a sense of awe and reverence. Moreover, we cannot fail to be struck by the obvious resemblance of living organs to the carefully planned designs of human engineers. The argument was most famously expressed in the watchmaker analogy of the eighteenth-century priest William Paley. Even if you didn't know what a watch was, the obviously designed character of its cogs and springs and of how they mesh together for a purpose would force you to conclude "that the watch must have had a maker: that there must have existed, at some time, and at some place or other, an artificer or artificers, who formed it for the purpose which we find it actually to answer; who comprehended its construction, and designed its use." If this is true of a comparatively simple watch, how much the more so is it true of the eye, ear, kidney, elbow joint, brain? These beautiful, complex, intricate, and obviously purpose-built structures must have had their own designer, their own watchmaker - God.

So ran Paley's argument, and it is an argument that nearly all thoughtful and sensitive people discover for themselves at some stage in their childhood. Throughout most of history it must have seemed utterly convincing, self-evidently true. And yet, as the result of one of the most astonishing intellectual revolutions in history, we now know that it is wrong, or at least superfluous. We now know that the order and apparent purposefulness of the living world has come about through an entirely different process, a process that works without the need for any designer and one that is a consequence of basically very simple laws of physics. This is the process of evolution by natural selection, discovered by Charles Darwin and, independently, by Alfred Russel Wallace.

What do all objects that look as if they must have had a designer have in common? The answer is statistical improbability. If we find a transparent pebble washed into the shape of a crude lens by the sea, we do not conclude that it must have been designed by an

optician: the unaided laws of physics are capable of achieving this result; it is not too improbable to have just "happened." But if we find an elaborate compound lens, carefully corrected against spherical and chromatic aberration, coated against glare, and with "Carl Zeiss" engraved on the rim, we know that it could not have just happened by chance. If you take all the atoms of such a compound lens and throw them together at random under the jostling influence of the ordinary laws of physics in nature, it is *theoretically* possible that, by sheer luck, the atoms would just happen to fall into the pattern of a Zeiss compound lens, and even that the atoms round the rim should happen to fall in such a way that the name Carl Zeiss is etched out. But the number of other ways in which the atoms could, with equal likelihood, have fallen, is so hugely, vastly, immeasurably greater that we can completely discount the chance hypothesis. Chance is out of the question as an explanation.

This is not a circular argument, by the way. It might seem to be circular because, it could be said, *any* particular arrangement of atoms is, with hindsight, very improbable. As has been said before, when a ball lands on a particular blade of grass on the golf course, it would be foolish to exclaim: "Out of all the billions of blades of grass that it *could* have fallen on, the ball actually fell on this one. How amazingly, miraculously improbable!" The fallacy here, of course, is that the ball had to land somewhere. We can only stand amazed at the improbability of the actual event if we specify it *a priori*: for example, if a blindfolded man spins himself round on the tee, hits the ball at random, and achieves a hole in one. That would be truly amazing, because the target destination of the ball is specified in advance.

Of all the trillions of different ways of putting together the atoms of a telescope, only a minority would actually work in some useful way. Only a tiny minority would have Carl Zeiss engraved on them, or, indeed, *any* recognizable words of any human language. The same goes for the parts of a watch: of all the billions of possible ways of putting them together, only a tiny minority will tell the time or do anything useful. And of course the same goes, *a fortiori*, for the parts of a living body. Of all the trillions of trillions of ways of putting together the parts of a body, only an infinitesimal minority would live, seek food, eat, and reproduce. True, there are many different ways of being alive - at least ten million different ways if we count the number of distinct species alive today - but, however many ways there may be of being alive, it is certain that there are vastly more ways of being dead!

We can safely conclude that living bodies are billions of times too complicated - too statistically improbable - to have come into being by sheer chance. How, then, did they come into being? The answer is that chance enters into the story, but not a single, monolithic act of chance. Instead, a whole series of tiny chance steps, each one small enough to be a believable product of its predecessor, occurred one after the other in sequence. These small steps of chance are caused by genetic mutations, random changes - mistakes really - in the genetic material. They give rise to changes in the existing bodily structure. Most of these changes are deleterious and lead to death. A minority of them turn out to be slight improvements, leading to increased survival and reproduction. By this process of natural selection, those random changes that turn out to be beneficial eventually spread through the species and become the norm. The stage is now set for the next small change in the evolutionary process. After, say, a thousand of these small changes in series, each change providing the basis for the next, the end result has become, by a process of accumulation, far too complex to have come about in a single act of chance.

For instance, it is theoretically possible for an eye to spring into being, in a single lucky step, from nothing: from bare skin, let's say. It is theoretically possible in the sense that a recipe could be written out in the form of a large number of mutations. If all these mutations happened simultaneously, a complete eye could, indeed, spring from nothing. But although it is theoretically possible, it is in practice inconceivable. The quantity of luck involved is much too large. The "correct" recipe involves changes in a huge number of genes simultaneously. The correct recipe is one particular combination of changes out of trillions of equally probable combinations of chances. We can certainly rule out such a miraculous coincidence. But it *is* perfectly plausible that the modern eye could have sprung from something almost the same as the modern eye but not quite: a very slightly less elaborate eye. By the same argument, this slightly less elaborate eye sprang from a slightly less elaborate eye still, and so on. If you assume a *sufficiently large number of sufficiently small differences* between each evolutionary stage and its predecessor, you are bound to be able to derive a full, complex, working eye from bare skin. How many intermediate stages are we allowed to postulate? That depends on how much time we have to play with. Has there been enough time for eyes to evolve by little steps from nothing?

The fossils tell us that life has been evolving on Earth for more than 3,000 million years. It is almost impossible for the human mind to grasp such an immensity of time. We, naturally and mercifully, tend to see our own expected lifetime as a fairly long time, but we can't expect to live even one century. It is 2,000 years since Jesus lived, a time span long enough to blur the distinction between history and myth. Can you imagine a million such periods laid end to end? Suppose we wanted to write the whole history on a single long scroll. If we crammed all of Common Era history into one metre of scroll, how long would the pre-Common Era part of the scroll, back to the start of evolution, be? The answer is that the pre-Common Era part of the scroll would stretch from Milan to Moscow. Think of the implications of this for the quantity of evolutionary change that can be accommodated. All the domestic breeds of dogs - Pekingeses, poodles, spaniels, Saint Bernards, and Chihuahuas - have come from wolves in a time span measured in hundreds or at the most thousands of years: no more than two meters along the road from Milan to Moscow. Think of the quantity of change involved in going from a wolf to a Pekingese; now multiply that quantity of change by a million. When you look at it like that, it becomes easy to believe that an eye could have evolved from no eye by small degrees.

It remains necessary to satisfy ourselves that every one of the intermediates on the evolutionary route, say from bare skin to a modern eye, would have been favored by natural selection; would have been an improvement over its predecessor in the sequence or at least would have survived. It is no good proving to ourselves that there is theoretically a chain of almost perceptibly different intermediates leading to an eye if many of those intermediates would have died. It is sometimes argued that the parts of an eye have to be all there together or the eye won't work at all. Half an eye, the argument runs, is no better than no eye at all. You can't fly with half a wing; you can't hear with half an ear. Therefore there can't have been a series of step-by-step intermediates leading up to a modern eye, wing, or ear.

This type of argument is so naive that one can only wonder at the subconscious motives for wanting to believe it. It is obviously not true that half an eye is useless. Cataract sufferers who have had their lenses surgically removed cannot see very well without glasses, but they are still much better off than people with no eyes at all. Without a lens you can't focus a detailed image, but you can avoid bumping into obstacles and you could

detect the looming shadow of a predator.

As for the argument that you can't fly with only half a wing, it is disproved by large numbers of very successful gliding animals, including mammals of many different kinds, lizards, frogs, snakes, and squids. Many different kinds of tree-dwelling animals have flaps of skin between their joints that really are fractional wings. If you fall out of a tree, any skin flap or flattening of the body that increases your surface area can save your life. And, however small or large your flaps may be, there must always be a critical height such that, if you fall from a tree of that height, your life would have been saved by just a little bit more surface area. Then, when your descendants have evolved that extra surface area, their lives would be saved by just a bit more still if they fell from trees of a slightly greater height. And so on by insensibly graded steps until, hundreds of generations later, we arrive at full wings.

Eyes and wings cannot spring into existence in a single step. That would be like having the almost infinite luck to hit upon the combination number that opens a large bank vault. But if you spun the dials of the lock at random, and every time you got a little bit closer to the lucky number the vault door creaked open another chink, you would soon have the door open! Essentially, that is the secret of how evolution by natural selection achieves what once seemed impossible. Things that cannot plausibly be derived from very different predecessors *can* plausibly be derived from only slightly different predecessors. Provided only that there is a sufficiently long series of such slightly different predecessors, you can derive anything from anything else.

Evolution, then, is theoretically *capable* of doing the job that, once upon a time, seemed to be the prerogative of God. But is there any evidence that evolution actually has happened? The answer is yes; the evidence is overwhelming. Millions of fossils are found in exactly the places and at exactly the depths that we should expect if evolution had happened. Not a single fossil has ever been found in any place where the evolution theory would not have expected it, although this *could* very easily have happened: a fossil mammal in rocks so old that fishes have not yet arrived, for instance, would be enough to disprove the evolution theory.

The patterns of distribution of living animals and plants on the continents and islands of the world is exactly what would be expected if they had evolved from common ancestors by slow, gradual degrees. The patterns of resemblance among animals and plants is exactly what we should expect if some were close cousins, and others more distant cousins to each other. The fact that the genetic code is the same in all living creatures overwhelmingly suggests that all are descended from one single ancestor. The evidence for evolution is so compelling that the only way to save the creation theory is to assume that God deliberately planted enormous quantities of evidence to make it *look* as if evolution had happened. In other words, the fossils, the geographical distribution of animals, and so on, are all one gigantic confidence trick. Does anybody want to worship a God capable of such trickery? It is surely far more reverent, as well as more scientifically sensible, to take the evidence at face value. All living creatures are cousins of one another, descended from one remote ancestor that lived more than 3,000 million years ago.

The Argument from Design, then, has been destroyed as a reason for believing in a God. Are there any other arguments? Some people believe in God because of what appears to them to be an inner revelation. Such revelations are not always edifying but they undoubtedly feel real to the individual concerned. Many inhabitants of lunatic asylums have

an unshakable inner faith that they are Napoleon or, indeed, God himself. There is no doubting the power of such convictions for those that have them, but this is no reason for the rest of us to believe them. Indeed, since such beliefs are mutually contradictory, we can't believe them all.

There is a little more that needs to be said. Evolution by natural selection explains a lot, but it couldn't start from nothing. It couldn't have started until there was some kind of rudimentary reproduction and heredity. Modern heredity is based on the DNA code, which is itself too complicated to have sprung spontaneously into being by a single act of chance. This seems to mean that there must have been some earlier hereditary system, now disappeared, which was simple enough to have arisen by chance and the laws of chemistry and which provided the medium in which a primitive form of cumulative natural selection could get started. DNA was a later product of this earlier cumulative selection. Before this original kind of natural selection, there was a period when complex chemical compounds were built up from simpler ones and before that a period when the chemical elements were built up from simpler elements, following the well-understood laws of physics. Before that, everything was ultimately built up from pure hydrogen in the immediate aftermath of the big bang, which initiated the universe.

There is a temptation to argue that, although God may not be needed to explain the evolution of complex order once the universe, with its fundamental laws of physics, had begun, we do need a God to explain the origin of all things. This idea doesn't leave God with very much to do: just set off the big bang, then sit back and wait for everything to happen. The physical chemist Peter Atkins, in his beautifully written book *The Creation*, postulates a lazy God who strove to do as little as possible in order to initiate everything. Atkins explains how each step in the history of the universe followed, by simple physical law, from its predecessor. He thus pares down the amount of work that the lazy creator would need to do and eventually concludes that he would in fact have needed to do nothing at all!

The details of the early phase of the universe belong to the realm of physics, whereas I am a biologist, more concerned with the later phases of the evolution of complexity. For me, the important point is that, even if the physicist needs to postulate an irreducible minimum that had to be present in the beginning, in order for the universe to get started, that irreducible minimum is certainly extremely simple. By definition, explanations that build on simple premises are more plausible and more satisfying than explanations that have to postulate complex and statistically improbable beginnings. And you can't get much more complex than an Almighty God!

When Religion Steps on Science's Turf
The Alleged Separation Between the Two Is Not So Tidy
by Richard Dawkins

The following article is from Free Inquiry magazine, Volume 18, Number 2.

A cowardly flabbiness of the intellect afflicts otherwise rational people confronted with long-established religions (though, significantly, not in the face of younger traditions such as Scientology or the Moonies). S. J. Gould, commenting in his Natural History column on the pope's attitude to evolution, is representative of a dominant strain of conciliatory thought, among believers and nonbelievers alike: "Science and religion are not in conflict, for their teachings occupy distinctly different domains ... I believe, with all my heart, in a respectful, even loving concordat [my emphasis] ...."

Well, what are these two distinctly different domains, these "Nonoverlapping Magisteria" that should snuggle up together in a respectful and loving concordat? Gould again: "The net of science covers the empirical universe: what is it made of (fact) and why does it work this way (theory). The net of religion extends over questions of moral meaning and value."

Who Owns Morals?
Would that it were that tidy. In a moment I'll look at what the pope actually says about evolution, and then at other claims of his church, to see if they really are so neatly distinct from the domain of science. First though, a brief aside on the claim that religion has some special expertise to offer us on moral questions. This is often blithely accepted even by the nonreligious, presumably in the course of a civilized "bending over backwards" to concede the best point your opponent has to offer - however weak that best point may be.

The question, "What is right and what is wrong?" is a genuinely difficult question that science certainly cannot answer. Given a moral premise or a priori moral belief, the important and rigorous discipline of secular moral philosophy can pursue scientific or logical modes of reasoning to point up hidden implications of such beliefs, and hidden inconsistencies between them. But the absolute moral premises themselves must come from elsewhere, presumably from unargued conviction. Or, it might be hoped, from religion - meaning some combination of authority, revelation, tradition, and scripture.

Unfortunately, the hope that religion might provide a bedrock, from which our otherwise sand-based morals can be derived, is a forlorn one. In practice, no civilized person uses Scripture as ultimate authority for moral reasoning. Instead, we pick and choose the nice bits of Scripture (like the Sermon on the Mount) and blithely ignore the nasty bits (like the obligation to stone adulteresses, execute apostates, and punish the grandchildren of offenders). The God of the Old Testament himself, with his pitilessly vengeful jealousy, his racism, sexism, and terrifying bloodlust, will not be adopted as a literal role model by anybody you or I would wish to know. Yes, of course it is unfair to judge the customs of an earlier era by the enlightened standards of our own. But that is precisely my point! Evidently, we have some alternative source of ultimate moral conviction that overrides Scripture when it suits us.

That alternative source seems to be some kind of liberal consensus of decency and natural justice that changes over historical time, frequently under the influence of secular reformists. Admittedly, that doesn't sound like bedrock. But in practice we, including the religious among us, give it higher priority than Scripture. In practice we more or less ignore Scripture, quoting it when it supports our liberal consensus, quietly forgetting it when it doesn't. And wherever that liberal consensus comes from, it is available to all of us, whether we are religious or not.

Similarly, great religious teachers like Jesus or Gautama Buddha may inspire us, by their good example, to adopt their personal moral convictions. But again we pick and choose among religious leaders, avoiding the bad examples of Jim Jones or Charles Manson, and we may choose good secular role models such as Jawaharlal Nehru or Nelson Mandela. Traditions too, however anciently followed, may be good or bad, and we use our secular judgment of decency and natural justice to decide which ones to follow, which to give up.

Religion on Science's Turf

But that discussion of moral values was a digression. I now turn to my main topic of evolution and whether the pope lives up to the ideal of keeping off the scientific grass. His "Message on Evolution to the Pontifical Academy of Sciences" begins with some casuistical doubletalk designed to reconcile what John Paul II is about to say with the previous, more equivocal pronouncements of Pius XII, whose acceptance of evolution was comparatively grudging and reluctant. Then the pope comes to the harder task of reconciling scientific evidence with "revelation."

Revelation teaches us that [man] was created in the image and likeness of God. ... if the human body takes its origin from pre-existent living matter, the spiritual soul is immediately created by God ... Consequently, theories of evolution which, in accordance with the philosophies inspiring them, consider the mind as emerging from the forces of living matter, or as a mere epiphenomenon of this matter, are incompatible with the truth about man. ... With man, then, we find ourselves in the presence of an ontological difference, an ontological leap, one could say.

To do the pope credit, at this point he recognizes the essential contradiction between the two positions he is attempting to reconcile: "However, does not the posing of such ontological discontinuity run counter to that physical continuity which seems to be the main thread of research into evolution in the field of physics and chemistry?"

Never fear. As so often in the past, obscurantism comes to the rescue:

Consideration of the method used in the various branches of knowledge makes it possible to reconcile two points of view which would seen irreconcilable. The sciences of observation describe and measure the multiple manifestations of life with increasing precision and correlate them with the time line. The moment of transition to the spiritual cannot be the object of this kind of observation, which nevertheless can discover at the experimental level a series of very valuable signs indicating what is specific to the human being.

In plain language, there came a moment in the evolution of hominids when God intervened and injected a human soul into a previously animal lineage. (When? A million years ago? Two million years ago? Between Homo erectus and Homo sapiens? Between "archaic" Homo sapiens and H. sapiens sapiens?) The sudden injection is necessary, of course, otherwise there would be no distinction upon which to base Catholic morality, which is speciesist to the core. You can kill adult animals for meat, but abortion and euthanasia are murder because human life is involved.

Catholicism's "net" is not limited to moral considerations, if only because Catholic morals have scientific implications. Catholic morality demands the presence of a great gulf between Homo sapiens and the rest of the animal kingdom. Such a gulf is fundamentally anti-evolutionary. The sudden injection of an immortal soul in the timeline is an anti-evolutionary intrusion into the domain of science.

More generally it is completely unrealistic to claim, as Gould and many others do, that religion keeps itself away from science's turf, restricting itself to morals and values. A universe with a supernatural presence would be a fundamentally and qualitatively different kind of universe from one without. The difference is, inescapably, a scientific difference. Religions make existence claims, and this means scientific claims.

The same is true of many of the major doctrines of the Roman Catholic Church. The Virgin Birth, the bodily Assumption of the Blessed Virgin Mary, the Resurrection of Jesus, the survival of our own souls after death: these are all claims of a clearly scientific nature. Either Jesus had a corporeal father or he didn't. This is not a question of "values" or "morals"; it is a question of sober fact. We may not have the evidence to answer it, but it is a scientific question, nevertheless. You may be sure that, if any evidence supporting the claim were discovered, the Vatican would not be reticent in promoting it.

Either Mary's body decayed when she died, or it was physically removed from this planet to Heaven. The official Roman Catholic doctrine of Assumption, promulgated as recently as 1950, implies that Heaven has a physical location and exists in the domain of physical reality - how else could the physical body of a woman go there? I am not, here, saying that the doctrine of the Assumption of the Virgin is necessarily false (although of course I think it is). I am simply rebutting the claim that it is outside the domain of science. On the contrary, the Assumption of the Virgin is transparently a scientific theory. So is the theory that our souls survive bodily death, and so are all stories of angelic visitations, Marian manifestations, and miracles of all types.

There is something dishonestly self-serving in the tactic of claiming that all religious beliefs are outside the domain of science. On the one hand, miracle stories and the promise of life after death are used to impress simple people, win converts, and swell congregations. It is precisely their scientific power that gives these stories their popular appeal. But at the same time it is considered below the belt to subject the same stories to the ordinary rigors of scientific criticism: these are religious matters and therefore outside the domain of science. But you cannot have it both ways. At least, religious theorists and apologists should not be allowed to get away with having it both ways. Unfortunately all too many of us, including nonreligious people, are unaccountably ready to let them.

I suppose it is gratifying to have the pope as an ally in the struggle against fundamentalist creationism. It is certainly amusing to see the rug pulled out from under the feet of Catholic creationists such as Michael Behe. Even so, given a choice between honest-to-goodness fundamentalism on the one hand, and the obscurantist, disingenuous doublethink of the Roman Catholic Church on the other, I know which I prefer.

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Dancing to the music of DNA

Richard Dawkins has become Professor of Public Understanding of Science. But can he reconcile us to his bleak truths about God, asks Megan Tresidder

THE BIOLOGIST, Dr Richard Dawkins, has just been mad'-Professor of Public Under-standing of Science at Oxford. a chair personally funded by Charles Simonyi of Microsoft. There are many reasons why this is a brilliant appointment, but Dawkins critics reckon it has flaws too.
Dawkins is a superb communicator. His books, The Selfish Gene, The Blind Watchmaker and his latest best-seller, River Out Of Eden, are some of the best books ever written on science. Dawkins writes beautifully and clearly, navigating you through subjects like genetics that you may have despaired of ever undemanding. He wins literary prizes as well as scientific ones and his arguments are so forceful that readers have actually written to say he made them abandon religion.
He has good looks (the Tom Stoppard of zoology), which adds to his success. But he also has a reputation as a bully, firing off letters to newspapers to hector opponents. He has described religious belief as "a virus". His critics accuse him of an unscientific lack of doubt of being messianic in his Darwinism.

He is often called a militant atheist. "Well, I'm also an afairyist," he says. "But there's no need to be a militant afairyist, because one is not constantly beset by people banging on about fairies."
He lives in Oxford, where he has worked for most of his life. He shares a New College flat with his wife, Lalla Ward. Dawkins is a small, elegant 54-year-old, and like his books, is breathtakingly articulate and self-assured. His manner is both charming and testy, in the politest possible way. He is a master at the put-down -- a favourite word is "silly" - but he is even better at inspiring you, which makes you for-give him his trespasses, several times over.
He takes up his new post in October, on top of his current one as Ox-ford's Reader in Zoology. The new job will mean writing more books and giving more public lectures. He is less keen to be used as a pundit every time a science story, like the latest one about falling sperm counts, hits the headlines.
"I am uneasily aware that I may be phoned up to comment on such issues but - not wanting to sound pretentious about this - I have a more cosmic view of science, which is timeless and doesn't depend on what happens to be in the week's news. I write about the deep questions of existence. It's a different understanding of science from those who are interested in the relationship of science to technology, or why non-stick frying pans work."
What he will do best is what he does in his books, finding brilliant metaphors for complex ideas. In one phrase - The Selfish Gene - he expressed the whole theory of
not of species or of individuals, but of genes, who simply use our bodies as vehicles in the relentless fight for self-replication.
In his latest book. he uses the metaphor of a river to explain the flow through time of DNA. the genetic messenger. The discovery of DNA, he says. means that Darwin-ism can be retold digitally; there is no need for any other explanation of the universe beyond that of the selfishness of the gene. There is "no de-sign, no purpose, no evil and good, nothing but blind pitiless indifference ... DNA neither knows nor cares. DNA just is. And we dance to its music."
It is wonderful! stuff, which in beautiful prose answers a lot of questions about how we came to be. But Dawkins is not so good on the "why" questions that the public might want answered. He is scornful of debate about the existence of God. Last year, he said religious people confronted with science were "know-nothings" and "no contests".
"Scorn," he says now, "was very probably a tactical error. I am going to have to clean up my act perhaps. I do value clarity of thought and so when people ask a why question, I do rather briskly demand to know what they mean by it."
"So if I ask why I am here?"
"My answer to that would depend on what you mean by that question," says Dawkins. "If you mean what is the ultimate purpose for my existence, that is a question that should never be put a question that doesn't deserve an answer."
"Why not?"
"To put it slightly closer to the knuckle, when someone suffers a dreadful tragedy, the natural response is to ask, why me? What have I done to deserve this? But you have done nothing to deserve it. And your question - why I am here? - really only means some-thing if you are religious. The onus is on religious people to prove their point of view, not on me. Unless there is a good reason to assume that something exists, you're better off assuming that it doesn't."
Even if he can't offer an alternative answer? In his new book, he writes that in the beginning, there was "the arising of some kind of self-copying system ..."
A bit woolly, that "arising', isn't it?
"When something happened 4,000 million years ago you would surely not expect me to fill in every last detail of what happened: You could ask me about how a car works and I could describe it generally but I might not be able to say exactly how the first spark is made. Would you then say that must mean it comes from God"
Is he interested in finding out about the first spark the universe? "No. I don't think that is a particularly interesting stage in the process. Other people do and they are working on it ... Well, of course it is interesting," he corrects himself, "but in some people's minds it is inflated as the great mystery.
"But every step in evolution has an element of chance. The origin of life, of the first self-replicating entity. was one of those chance processes. The origin of sex is another. I don't particularly want to study the origin of life. I would rather study the origin
Does he actually enjoy provoking controversy?
"Not much," he says, a little doubtfully. "I would much rather open people's eyes to the wonders of the world they have been born into. We get jaded, don't we, be-cause it all becomes so familiar?"
There is a theory about Dawkins, that he must have had a traumatic experience with religion to have ended up so ferociously against it, but he denies that. He was born in Kenya and moved to Britain when small, when his father - a biologist - inherited a farm in Oxfordshire. Dawkins attended church as a child but rejected it in his teens, when he discovered Darwinism. He says there was no blinding flash. Quite the contrary, since he was at first tempted to reject Darwinism as too simple, which may be why Darwinism emerged so late.
"When you think of how fantastically simple an idea it is compared to the ideas of the Greeks, of New-ton, of the great philosophers, it is astonishing that it took until the 19th century to emerge. But maybe it was because of the sheer audacity of explaining the prodigious complexity and beauty of living things by such a simple principle."

DAWKINS thinks the reason why Darwinism is still challenged today is that its critics are too literal about applying the theory of natural selection to our sophisticated selves. "If you went back a million years to our ancestors in Africa - to Homo Erectus - you probably would have been satisfied that natural selection explained everything about them. Now vie are feather-bedded away from the cutting edge of natural selection in all sorts of ways."
But that doesn't mean, he explains, that natural selection is a bankrupt idea It just means that the original rules are operating in a new environment Sex with contraception makes no earthly Darwinian sense, "until you realise that it is a 1 good rule of thumb that we should enjoy sex. Lust works as a rule of thumb in the wild and therefore we
Sometimes, the rules go wrong - as when a moth flies into a candle, mistaking it for the rays of the moon, by which it sets its compass. Dawkins has an idea involving moths. He will one day take a computer with a touch-activated screen into the garden. On the screen, there will be abstract computerised images which could, with improvement, look like flowers. He will wait for moths to alight on the screen and choose the most potentially flower-like images, editing out the less satisfactory ones. Leaving aside the obvious cheap point that the whole thing has had to be set up by him, playing God, he says it could be vivid proof of evolution by information selection.
Could it be then, accepting Dawkins's model of life as nothing but the flow of bytes, that God is a computer? That is the suggestion in a book by Frank Tipler, the physicist, who argues that God will reveal himself at the point of infinite, digital knowledge.
"If you define God as a being of vastly greater intelligence than you or I, God could be a computer or a superior being on another planet," says Dawkins. 'That would be wonderful. I wouldn't want to call it God because of all the other associations. But that something would be the end-product, which had come about through a long process of evolution. I don't mind how complicated, how all-knowing, how all-powerful that something might be - if it was the end-product of evolution - because we would have an explanation of how it came into existence. But God is usually taken to mean something that was there at the beginning, another matter entirely."
A matter on which there is no doubt where he stands. Does Dawkins accept that he is a scientist who is particularly free of doubt?
"No," he says. "I have deep, deep questions about the origins of consciousness. It is very difficult to even think of what it means, let alone how natural selection favoured it. No, It is just that my doubts are confined to more interesting questions than the existence of God."

Religion's misguided missiles

Promise a young man that death is not the end and he will willingly cause disaster

The following Richard Dawkins essay appeared in the popular U.K. news website,The Guardian on September 15, 2001, four days after the World Trade Center terrorist attack.

A guided missile corrects its trajectory as it flies, homing in, say, on the heat of a jet plane's exhaust. A great improvement on a simple ballistic shell, it still cannot discriminate particular targets. It could not zero in on a designated New York skyscraper if launched from as far away as Boston.

That is precisely what a modern "smart missile" can do. Computer miniaturisation has advanced to the point where one of today's smart missiles could be programmed with an image of the Manhattan skyline together with instructions to home in on the north tower of the World Trade Centre. Smart missiles of this sophistication are possessed by the United States, as we learned in the Gulf war, but they are economically beyond ordinary terrorists and scientifically beyond theocratic governments. Might there be a cheaper and easier alternative?

In the second world war, before electronics became cheap and miniature, the psychologist BF Skinner did some research on pigeon-guided missiles. The pigeon was to sit in a tiny cockpit, having previously been trained to peck keys in such a way as to keep a designated target in the centre of a screen. In the missile, the target would be for real.

The principle worked, although it was never put into practice by the US authorities. Even factoring in the costs of training them, pigeons are cheaper and lighter than computers of comparable effectiveness. Their feats in Skinner's boxes suggest that a pigeon, after a regimen of training with colour slides, really could guide a missile to a distinctive landmark at the southern end of Manhattan island. The pigeon has no idea that it is guiding a missile. It just keeps on pecking at those two tall rectangles on the screen, from time to time a food reward drops out of the dispenser, and this goes on until... oblivion.

Pigeons may be cheap and disposable as on-board guidance systems, but there's no escaping the cost of the missile itself. And no such missile large enough to do much damage could penetrate US air space without being intercepted. What is needed is a missile that is not recognised for what it is until too late. Something like a large civilian airliner, carrying the innocuous markings of a well-known carrier and a great deal of fuel. That's the easy part. But how do you smuggle on board the necessary guidance system? You can hardly expect the pilots to surrender the left-hand seat to a pigeon or a computer.

How about using humans as on-board guidance systems, instead of pigeons? Humans are at least as numerous as pigeons, their brains are not significantly costlier than pigeon brains, and for many tasks they are actually superior. Humans have a proven track record in taking over planes by the use of threats, which work because the legitimate pilots value their own lives and those of their passengers.

The natural assumption that the hijacker ultimately values his own life too, and will act rationally to preserve it, leads air crews and ground staff to make calculated decisions that

would not work with guidance modules lacking a sense of self-preservation. If your plane is being hijacked by an armed man who, though prepared to take risks, presumably wants to go on living, there is room for bargaining. A rational pilot complies with the hijacker's wishes, gets the plane down on the ground, has hot food sent in for the passengers and leaves the negotiations to people trained to negotiate.

The problem with the human guidance system is precisely this. Unlike the pigeon version, it knows that a successful mission culminates in its own destruction. Could we develop a biological guidance system with the compliance and dispensability of a pigeon but with a man's resourcefulness and ability to infiltrate plausibly? What we need, in a nutshell, is a human who doesn't mind being blown up. He'd make the perfect on-board guidance system. But suicide enthusiasts are hard to find. Even terminal cancer patients might lose their nerve when the crash was actually looming.

Could we get some otherwise normal humans and somehow persuade them that they are not going to die as a consequence of flying a plane smack into a skyscraper? If only! Nobody is that stupid, but how about this - it's a long shot, but it just might work. Given that they are certainly going to die, couldn't we sucker them into believing that they are going to come to life again afterwards? Don't be daft! No, listen, it might work. Offer them a fast track to a Great Oasis in the Sky, cooled by everlasting fountains. Harps and wings wouldn't appeal to the sort of young men we need, so tell them there's a special martyr's reward of 72 virgin brides, guaranteed eager and exclusive.

Would they fall for it? Yes, testosterone-sodden young men too unattractive to get a woman in this world might be desperate enough to go for 72 private virgins in the next.

It's a tall story, but worth a try. You'd have to get them young, though. Feed them a complete and self-consistent background mythology to make the big lie sound plausible when it comes. Give them a holy book and make them learn it by heart. Do you know, I really think it might work. As luck would have it, we have just the thing to hand: a ready-made system of mind-control which has been honed over centuries, handed down through generations. Millions of people have been brought up in it. It is called religion and, for reasons which one day we may understand, most people fall for it (nowhere more so than America itself, though the irony passes unnoticed). Now all we need is to round up a few of these faith-heads and give them flying lessons.

Facetious? Trivialising an unspeakable evil? That is the exact opposite of my intention, which is deadly serious and prompted by deep grief and fierce anger. I am trying to call attention to the elephant in the room that everybody is too polite - or too devout - to notice: religion, and specifically the devaluing effect that religion has on human life. I don't mean devaluing the life of others (though it can do that too), but devaluing one's own life. Religion teaches the dangerous nonsense that death is not the end.

If death is final, a rational agent can be expected to value his life highly and be reluctant to risk it. This makes the world a safer place, just as a plane is safer if its hijacker wants to survive. At the other extreme, if a significant number of people convince themselves, or are convinced by their priests, that a martyr's death is equivalent to pressing the hyperspace button and zooming through a wormhole to another universe, it can make the world a very dangerous place. Especially if they also believe that that other universe is a paradisical

escape from the tribulations of the real world. Top it off with sincerely believed, if ludicrous and degrading to women, sexual promises, and is it any wonder that naive and frustrated young men are clamouring to be selected for suicide missions?

There is no doubt that the afterlife-obsessed suicidal brain really is a weapon of immense power and danger. It is comparable to a smart missile, and its guidance system is in many respects superior to the most sophisticated electronic brain that money can buy. Yet to a cynical government, organisation, or priesthood, it is very very cheap.

Our leaders have described the recent atrocity with the customary cliche: mindless cowardice. "Mindless" may be a suitable word for the vandalising of a telephone box. It is not helpful for understanding what hit New York on September 11. Those people were not mindless and they were certainly not cowards. On the contrary, they had sufficiently effective minds braced with an insane courage, and it would pay us mightily to understand where that courage came from.

It came from religion. Religion is also, of course, the underlying source of the divisiveness in the Middle East which motivated the use of this deadly weapon in the first place. But that is another story and not my concern here. My concern here is with the weapon itself. To fill a world with religion, or religions of the Abrahamic kind, is like littering the streets with loaded guns. Do not be surprised if they are used.

Viruses of the Mind
Richard Dawkins

1991

> The haven all memes depend on reaching is the human mind, but a human mind is itself an artifact created when memes restructure a human brain in order to make it a better habitat for memes. The avenues for entry and departure are modified to suit local conditions, and strengthened by various artificial devices that enhance fidelity and prolixity of replication: native Chinese minds differ dramatically from native French minds, and literate minds differ from illiterate minds. What memes provide in return to the organisms in which they reside is an incalculable store of advantages --- with some Trojan horses thrown in for good measure. . .
>
> Daniel Dennett, *Consciousness Explained*

1 Duplication Fodder

A beautiful child close to me, six and the apple of her father's eye, believes that Thomas the Tank Engine really exists. She believes in Father Christmas, and when she grows up her ambition is to be a tooth fairy. She and her school-friends believe the solemn word of respected adults that tooth fairies and Father Christmas really exist. This little girl is of an age to believe whatever you tell her. If you tell her about witches changing princes into frogs she will believe you. If you tell her that bad children roast forever in hell she will have nightmares. I have just discovered that without her father's consent this sweet, trusting, gullible six-year-old is being sent, for weekly instruction, to a Roman Catholic nun. What chance has she?

A human child is shaped by evolution to soak up the culture of her people. Most obviously, she learns the essentials of their language in a matter of months. A large dictionary of words to speak, an encyclopedia of information to speak about, complicated syntactic and semantic rules to order the speaking, are all transferred from older brains into hers well before she reaches half her adult size. When you are pre-programmed to absorb useful information at a high rate, it is hard to shut out pernicious or damaging information at the same time. With so many mindbytes to be downloaded, so many mental codons to be replicated, it is no wonder that child brains are gullible, open to almost any suggestion, vulnerable to subversion, easy prey to Moonies, Scientologists and nuns. Like immune-deficient patients, children are wide open to mental infections that adults might brush off without effort.

DNA, too, includes parasitic code. Cellular machinery is extremely good at copying DNA. Where DNA is concerned, it seems to have an eagerness to copy, seems eager to be copied. The cell nucleus is a paradise for DNA, humming with sophisticated, fast, and accurate duplicating machinery.

Cellular machinery is so friendly towards DNA duplication that it is small wonder cells play host to DNA parasites --- viruses, viroids, plasmids and a riff-raff of other genetic fellow travelers. Parasitic DNA even gets itself spliced seamlessly into the chromosomes themselves. ``Jumping genes'' and stretches of ``selfish DNA'' cut or copy themselves out of chromosomes and paste themselves in elsewhere. Deadly oncogenes are almost impossible to distinguish from the legitimate genes

between which they are spliced. In evolutionary time, there is probably a continual traffic from ``straight" genes to ``outlaw," and back again (Dawkins, 1982). DNA is just DNA. The only thing that distinguishes viral DNA from host DNA is its expected method of passing into future generations. ``Legitimate" host DNA is just DNA that aspires to pass into the next generation via the orthodox route of sperm or egg. ``Outlaw" or parasitic DNA is just DNA that looks to a quicker, less cooperative route to the future, via a squeezed droplet or a smear of blood, rather than via a sperm or egg.

For data on a floppy disc, a computer is a humming paradise just as cell nuclei hum with eagerness to duplicate DNA. Computers and their associated disc and tape readers are designed with high fidelity in mind. As with DNA molecules, magnetized bytes don't literally ``want" to be faithfully copied. Nevertheless, you can write a computer program that takes steps to duplicate itself. Not just duplicate itself within one computer but spread itself to other computers. Computers are so good at copying bytes, and so good at faithfully obeying the instructions contained in those bytes, that they are sitting ducks to self-replicating programs: wide open to subversion by software parasites. Any cynic familiar with the theory of selfish genes and memes would have known that modern personal computers, with their promiscuous traffic of floppy discs and e-mail links, were just asking for trouble. The only surprising thing about the current epidemic of computer viruses is that it has been so long in coming.

2 Computer Viruses: a Model for an Informational Epidemiology

Computer viruses are pieces of code that graft themselves into existing, legitimate programs and subvert the normal actions of those programs. They may travel on exchanged floppy disks, or over networks. They are technically distinguished from ``worms" which are whole programs in their own right, usually traveling over networks. Rather different are ``Trojan horses," a third category of destructive programs, which are not in themselves self-replicating but rely on humans to replicate them because of their pornographic or otherwise appealing content. Both viruses and worms are programs that actually say, in computer language, ``Duplicate me." Both may do other things that make their presence felt and perhaps satisfy the hole-in-corner vanity of their authors. These side-effects may be ``humorous" (like the virus that makes the Macintosh's built-in loudspeaker enunciate the words ``Don't panic," with predictably opposite effect); malicious (like the numerous IBM viruses that erase the hard disk after a sniggering screen-announcement of the impending disaster); political (like the Spanish Telecom and Beijing viruses that protest about telephone costs and massacred students respectively); or simply inadvertent (the programmer is incompetent to handle the low-level system calls required to write an effective virus or worm). The famous Internet Worm, which paralyzed much of the computing power of the United States on November 2, 1988, was not intended (very) maliciously but got out of control and, within 24 hours, had clogged around 6,000 computer memories with exponentially multiplying copies of itself.

``Memes now spread around the world at the speed of light, and replicate at rates that make even fruit flies and yeast cells look glacial in comparison. They leap promiscuously from vehicle to vehicle, and from medium to medium, and are proving to be virtually unquarantinable" (Dennett 1990, p.131). Viruses aren't limited to electronic media such as disks and data lines. On its way from one computer to another, a virus may pass through printing ink, light rays in a human lens, optic nerve impulses and finger muscle contractions. A computer fanciers' magazine that printed the text of a virus program for the interest of its readers has been widely condemned. Indeed, such is the appeal of the virus idea to a certain kind of puerile mentality (the masculine gender is used advisedly), that publication of any kind of ``how to" information on designing virus programs is rightly seen as an irresponsible act.

I am not going to publish any virus code. But there are certain tricks of effective virus design that are sufficiently well known, even obvious, that it will do no harm to mention them, as I need to do to develop my theme. They all stem from the virus's need to evade detection while it is spreading.

A virus that clones itself too prolifically within one computer will soon be detected because the symptoms of clogging will become too obvious to ignore. For this reason many virus programs check, before infecting a system, to make sure that they are not already on that system. Incidentally, this opens the way for a defense against viruses that is analogous to immunization. In the days before a specific anti-virus program was available, I myself responded to an early infection of my own hard disk by means of a crude ``vaccination." Instead of deleting the virus that I had detected, I simply disabled its coded instructions, leaving the ``shell" of the virus with its characteristic external ``signature" intact. In theory, subsequent members of the same virus species that arrived in my system should have recognized the signature of their own kind and refrained from trying to double-infect. I don't know whether this immunization really worked, but in those days it probably was worth while ``gutting" a virus and leaving a shell like this, rather than simply removing it lock, stock and barrel. Nowadays it is better to hand the problem over to one of the professionally written anti-virus programs.

A virus that is too virulent will be rapidly detected and scotched. A virus that instantly and catastrophically sabotages every computer in which it finds itself will not find itself in many computers. It may have a most amusing effect on one computer ---- erase an entire doctoral thesis or something equally side-splitting --- but it won't spread as an epidemic.

Some viruses, therefore, are designed to have an effect that is small enough to be difficult to detect, but which may nevertheless be extremely damaging. There is one type, which, instead of erasing disk sectors wholesale, attacks only spreadsheets, making a few random changes in the (usually financial) quantities entered in the rows and columns. Other viruses evade detection by being triggered probabilistically, for example erasing only one in 16 of the hard disks infected. Yet other viruses employ the time-bomb principle. Most modern computers are ``aware" of the date, and viruses have been triggered to manifest themselves all around the world, on a particular date such as Friday 13th or April Fool's Day. From the parasitic point of view, it doesn't matter how catastrophic the eventual attack is, provided the virus has had plenty of opportunity to spread first (a disturbing analogy to the Medawar/Williams theory of ageing: we are the victims of lethal and sub-lethal genes that mature only after we have had plenty of time to reproduce (Williams, 1957)). In defense, some large companies go so far as to set aside one ``miner's canary" among their fleet of computers, and advance its internal calendar a week so that any time-bomb viruses will reveal themselves prematurely before the big day.

Again predictably, the epidemic of computer viruses has triggered an arms race. Anti-viral software is doing a roaring trade. These antidote programs -- ``Interferon," ``Vaccine," ``Gatekeeper" and others --- employ a diverse armory of tricks. Some are written with specific, known and named viruses in mind. Others intercept any attempt to meddle with sensitive system areas of memory and warn the user.

The virus principle could, in theory, be used for non-malicious, even beneficial purposes. Thimbleby (1991) coins the phrase ``liveware" for his already-implemented use of the infection principle for keeping multiple copies of databases up to date. Every time a disk containing the database is

plugged into a computer, it looks to see whether there is already another copy present on the local hard disk. If there is, each copy is updated in the light of the other. So, with a bit of luck, it doesn't matter which member of a circle of colleagues enters, say, a new bibliographical citation on his personal disk. His newly entered information will readily infect the disks of his colleagues (because the colleagues promiscuously insert their disks into one another's computers) and will spread like an epidemic around the circle. Thimbleby's liveware is not entirely virus-like: it could not spread to just anybody's computer and do damage. It spreads data only to already-existing copies of its own database; and you will not be infected by liveware unless you positively opt for infection.

Incidentally, Thimbleby, who is much concerned with the virus menace, points out that you can gain some protection by using computer systems that other people don't use. The usual justification for purchasing today's numerically dominant computer is simply and solely that it *is* numerically dominant. Almost every knowledgeable person agrees that, in terms of quality and especially user-friendliness, the rival, minority system is superior. Nevertheless, ubiquity is held to be good in itself, sufficient to outweigh sheer quality. Buy the same (albeit inferior) computer as your colleagues, the argument goes, and you'll be able to benefit from shared software, and from a generally large circulation of available software. The irony is that, with the advent of the virus plague, ``benefit'' is not all that you are likely to get. Not only should we all be very hesitant before we accept a disk from a colleague. We should also be aware that, if we join a large community of users of a particular make of computer, we are also joining a large community of viruses --- even, it turns out, *disproportionately* larger.

Returning to possible uses of viruses for positive purposes, there are proposals to exploit the ``poacher turned gamekeeper'' principle, and ``set a thief to catch a thief.'' A simple way would be to take any of the existing anti-viral programs and load it, as a ``warhead,'' into a harmless self-replicating virus. From a ``public health'' point of view, a spreading epidemic of anti-viral software could be especially beneficial because the computers most vulnerable to malicious viruses --- those whose owners are promiscuous in the exchange of pirated programs --- will also be most vulnerable to infection by the healing anti-virus. A more penetrating anti-virus might --- as in the immune system --- ``learn'' or ``evolve'' an improved capacity to attack whatever viruses it encountered.

I can imagine other uses of the computer virus principle which, if not exactly altruistic, are at least constructive enough to escape the charge of pure vandalism. A computer company might wish to do market research on the habits of its customers, with a view to improving the design of future products. Do users like to choose files by pictorial icon, or do they opt to display them by textual name only? How deeply do people nest folders (directories) within one another? Do people settle down for a long session with only one program, say a word processors, or are they constantly switching back and forth, say between writing and drawing programs? Do people succeed in moving the mouse pointer straight to the target, or do they meander around in time-wasting hunting movements that could be rectified by a change in design?

The company could send out a questionnaire asking all these questions, but the customers that replied would be a biased sample and, in any case, their own assessment of their computer-using behavior might be inaccurate. A better solution would be a market-research computer program. Customers would be asked to load this program into their system where it would unobtrusively sit, quietly monitoring and tallying key-presses and mouse movements. At the end of a year, the customer would be asked to send in the disk file containing all the tallyings of the market-research program. But again, most people would not bother to cooperate and some might see it as an invasion of privacy and of their disk space.

The perfect solution, from the company's point of view, would be a virus. Like any other virus, it would be self-replicating and secretive. But it would not be destructive or facetious like an ordinary virus. Along with its self-replicating booster it would contain a market-research warhead. The virus would be released surreptitiously into the community of computer users. Just like an ordinary virus it would spread around, as people passed floppy disks and e-mail around the community. As the virus spread from computer to computer, it would build up statistics on users behavior, monitored secretly from deep within a succession of systems. Every now and again, a copy of the viruses would happen to find its way, by normal epidemic traffic, back into one of the company's own computers. There it would be debriefed and its data collated with data from other copies of the virus that had come ``home."

Looking into the future, it is not fanciful to imagine a time when viruses, both bad and good, have become so ubiquitous that we could speak of an ecological community of viruses and legitimate programs coexisting in the silicosphere. At present, software is advertised as, say, ``Compatible with System 7." In the future, products may be advertised as ``Compatible with all viruses registered in the 1998 World Virus Census; immune to all listed virulent viruses; takes full advantage of the facilities offered by the following benign viruses if present..." Word-processing software, say, may hand over particular functions, such as word-counting and string-searches, to friendly viruses burrowing autonomously through the text.

Looking even further into the future, whole integrated software systems might grow, not by design, but by something like the growth of an ecological community such as a tropical rain-forest. Gangs of mutually compatible viruses might grow up, in the same way as genomes can be regarded as gangs of mutually compatible genes (Dawkins, 1982). Indeed, I have even suggested that our genomes should be regarded as gigantic colonies of viruses (Dawkins, 1976). Genes cooperate with one another in genomes because natural selection has favored those genes that prosper in the presence of the other genes that happen to be common in the gene pool. Different gene pools may evolve towards different combinations of mutually compatible genes. I envisage a time when, in the same kind of way, computer viruses may evolve towards compatibility with other viruses, to form communities or gangs. But then again, perhaps not! At any rate, I find the speculation more alarming than exciting.

At present, computer viruses don't strictly evolve. They are invented by human programmers, and if they evolve they do so in the same weak sense as cars or aeroplanes evolve. Designers derive this year's car as a slight modification of last year's car, and then may, more or less consciously, continue a trend of the last few years --- further flattening of the radiator grill or whatever it may be. Computer virus designers dream up ever more devious tricks for outwitting the programmers of anti-virus software. But computer viruses don't --- so far --- mutate and evolve by true natural selection. They may do so in the future. Whether they evolve by natural selection, or whether their evolution is steered by human designers, may not make much difference to their eventual performance. By either kind of evolution, we expect them to become better at concealment, and we expect them to become subtly compatible with other viruses that are at the same time prospering in the computer community.

DNA viruses and computer viruses spread for the same reason: an environment exists in which there is machinery well set up to duplicate and spread them around and to obey the instructions that the viruses embody. These two environments are, respectively, the environment of cellular physiology and the environment provided by a large community of computers and data-handling machinery. Are there any other environments like these, any other humming paradises of replication?

3 The Infected Mind

I have already alluded to the programmed-in gullibility of a child, so useful for learning language and traditional wisdom, and so easily subverted by nuns, Moonies and their ilk. More generally, we all exchange information with one another. We don't exactly plug floppy disks into slots in one another's skulls, but we exchange sentences, both through our ears and through our eyes. We notice each other's styles of moving and dressing and are influenced. We take in advertising jingles, and are presumably persuaded by them, otherwise hard-headed businessmen would not spend so much money polluting their air with them.

Think about the two qualities that a virus, or any sort of parasitic replicator, demands of a friendly medium,. the two qualities that make cellular machinery so friendly towards parasitic DNA, and that make computers so friendly towards computer viruses. These qualities are, firstly, a readiness to replicate information accurately, perhaps with some mistakes that are subsequently reproduced accurately; and, secondly, a readiness to obey instructions encoded in the information so replicated.

Cellular machinery and electronic computers excel in both these virus-friendly qualities. How do human brains match up? As faithful duplicators, they are certainly less perfect than either cells or electronic computers. Nevertheless, they are still pretty good, perhaps about as faithful as an RNA virus, though not as good as DNA with all its elaborate proofreading measures against textual degradation. Evidence of the fidelity of brains, especially child brains, as data duplicators is provided by language itself. Shaw's Professor Higgins was able by ear alone to place Londoners in the street where they grew up. Fiction is not evidence for anything, but everyone knows that Higgins's fictional skill is only an exaggeration of something we can all down. Any American can tell Deep South from Mid West, New England from Hillbilly. Any New Yorker can tell Bronx from Brooklyn. Equivalent claims could be substantiated for any country. What this phenomenon means is that human brains are capable of pretty accurate copying (otherwise the accents of, say, Newcastle would not be stable enough to be recognized) but with some mistakes (otherwise pronunciation would not evolve, and all speakers of a language would inherit identically the same accents from their remote ancestors). Language evolves, because it has both the great stability and the slight changeability that are prerequisites for any evolving system.

The second requirement of a virus-friendly environment --- that it should obey a program of coded instructions --- is again only quantitatively less true for brains than for cells or computers. We sometimes obey orders from one another, but also we sometimes don't. Nevertheless, it is a telling fact that, the world over, the vast majority of children follow the religion of their parents rather than any of the other available religions. Instructions to genuflect, to bow towards Mecca, to nod one's head rhythmically towards the wall, to shake like a maniac, to ``speak in tongues'' --- the list of such arbitrary and pointless motor patterns offered by religion alone is extensive --- are obeyed, if not slavishly, at least with some reasonably high statistical probability.

Less portentously, and again especially prominent in children, the ``craze'' is a striking example of behavior that owes more to epidemiology than to rational choice. Yo-yos, hula hoops and pogo sticks, with their associated behavioral fixed actions, sweep through schools, and more sporadically leap from school to school, in patterns that differ from a measles epidemic in no serious particular. Ten years ago, you could have traveled thousands of miles through the United States and never seen a baseball cap turned back to front. Today, the reverse baseball cap is ubiquitous. I do not know what the pattern of geographical spread of the reverse baseball cap precisely was, but epidemiology is certainly among the professions primarily qualified to study it. We don't have to get into arguments about ``determinism''; we don't have to claim that children are compelled to imitate their

fellows' hat fashions. It is enough that their hat-wearing behavior, as a matter of fact, *is* statistically affected by the hat-wearing behavior of their fellows.

Trivial though they are, crazes provide us with yet more circumstantial evidence that human minds, especially perhaps juvenile ones, have the qualities that we have singled out as desirable for an informational parasite. At the very least the mind is a plausible *candidate* for infection by something like a computer virus, even if it is not quite such a parasite's dream-environment as a cell nucleus or an electronic computer.

It is intriguing to wonder what it might feel like, from the inside, if one's mind were the victim of a ``virus." This might be a deliberately designed parasite, like a present-day computer virus. Or it might be an inadvertently mutated and unconsciously evolved parasite. Either way, especially if the evolved parasite was the memic descendant of a long line of successful ancestors, we are entitled to expect the typical ``mind virus" to be pretty good at its job of getting itself successfully replicated.

Progressive evolution of more effective mind-parasites will have two aspects. New ``mutants" (either random or designed by humans) that are better at spreading will become more numerous. And there will be a ganging up of ideas that flourish in one another's presence, ideas that mutually support one another just as genes do and as I have speculated computer viruses may one day do. We expect that replicators will go around together from brain to brain in mutually compatible gangs. These gangs will come to constitute a package, which may be sufficiently stable to deserve a collective name such as Roman Catholicism or Voodoo. It doesn't too much matter whether we analogize the whole package to a single virus, to each one of the component parts to a single virus. The analogy is not that precise anyway, just as the distinction between a computer virus and a computer worm is nothing to get worked up about. What matters is that minds are friendly environments to parasitic, self-replicating ideas or information, and that minds are typically massively infected.

Like computer viruses, successful mind viruses will tend to be hard for their victims to detect. If you are the victim of one, the chances are that you won't know it, and may even vigorously deny it. Accepting that a virus might be difficult to detect in your own mind, what tell-tale signs might you look out for? I shall answer by imaging how a medical textbook might describe the typical symptoms of a sufferer (arbitrarily assumed to be male).

1. The patient typically finds himself impelled by some deep, inner conviction that something is true, or right, or virtuous: a conviction that doesn't seem to owe anything to evidence or reason, but which, nevertheless, he feels as totally compelling and convincing. We doctors refer to such a belief as ``faith."

2. Patients typically make a positive virtue of faith's being strong and unshakable, *in spite of* not being based upon evidence. Indeed, they may fell that the less evidence there is, the more virtuous the belief (see below).

This paradoxical idea that lack of evidence is a positive virtue where faith is concerned has something of the quality of a program that is self-sustaining, because it is self-referential (see the chapter ``On Viral Sentences and Self-Replicating Structures" in Hofstadter, 1985). Once the proposition is believed, it automatically undermines opposition to itself. The ``lack of evidence is a virtue" idea could be an admirable sidekick, ganging up with faith itself in a clique of mutually supportive viral programs.

3. A related symptom, which a faith-sufferer may also present, is the conviction that ``mystery," *per*

se, is a good thing. It is not a virtue to solve mysteries. Rather we should enjoy them, even revel in their insolubility.

Any impulse to solve mysteries could be serious inimical to the spread of a mind virus. It would not, therefore, be surprising if the idea that ``mysteries are better not solved" was a favored member of a mutually supporting gang of viruses. Take the ``Mystery of Transubstantiation." It is easy and non-mysterious to believe that in some symbolic or metaphorical sense the eucharistic wine turns into the blood of Christ. The Roman Catholic doctrine of transubstantiation, however, claims far more. The ``whole substance" of the wine is converted into the blood of Christ; the appearance of wine that remains is ``merely accidental," ``inhering in no substance" (Kenny, 1986, p. 72). Transubstantiation is colloquially taught as meaning that the wine ``literally" turns into the blood of Christ. Whether in its obfuscatory Aristotelian or its franker colloquial form, the claim of transubstantiation can be made only if we do serious violence to the normal meanings of words like ``substance" and ``literally." Redefining words is not a sin, but, if we use words like ``whole substance" and ``literally" for this case, what word are we going to use when we really and truly *want* to say that something did actually happen? As Anthony Kenny observed of his own puzzlement as a young seminarian, ``For all I could tell, my typewriter might be Benjamin Disraeli transubstantiated...."

Roman Catholics, whose belief in infallible authority compels them to accept that wine becomes physically transformed into blood despite all appearances, refer to the ``mystery" of transubstantiation. Calling it a mystery makes everything OK, you see. At least, it works for a mind well prepared by background infection. Exactly the same trick is performed in the ``mystery" of the Trinity. Mysteries are not meant to be solved, they are meant to strike awe. The ``mystery is a virtue" idea comes to the aid of the Catholic, who would otherwise find intolerable the obligation to believe the obvious nonsense of the transubstantiation and the ``three-in-one." Again, the belief that ``mystery is a virtue" has a self-referential ring. As Hofstadter might put it, the very mysteriousness of the belief moves the believer to perpetuate the mystery.

An extreme symptom of ``mystery is a virtue" infection is Tertullian's ``*Certum est quia impossibile est*" (It is certain because it is impossible"). That way madness lies. One is tempted to quote Lewis Carroll's White Queen, who, in response to Alice's ``One can't believe impossible things" retorted ``I daresay you haven't had much practice... When I was your age, I always did it for half-an-hour a day. Why, sometimes I've believed as many as six impossible things before breakfast." Or Douglas Adam's Electric Monk, a labor-saving device programmed to do your believing for you, which was capable of ``believing things they'd have difficulty believing in Salt Lake City" and which, at the moment of being introduced to the reader, believed, contrary to all the evidence, that everything in the world was a uniform shade of pink. But White Queens and Electric Monks become less funny when you realize that these virtuoso believers are indistinguishable from revered theologians in real life. ``It is by all means to be believed, because it is absurd" (Tertullian again). Sir Thomas Browne (1635) quotes Tertullian with approval, and goes further: ``Methinks there be not impossibilities enough in religion for an active faith." And ``I desire to exercise my faith in the difficultest point; for to credit ordinary and visible objects is not faith, but perswasion [sic]."

I have the feeling that something more interesting is going on here than just plain insanity or surrealist nonsense, something akin to the admiration we feel when we watch a ten-ball juggler on a tightrope. It is as though the faithful gain prestige through managing to believe even more impossible things than their rivals succeed in believing. Are these people testing --- exercising --- their believing muscles, training themselves to believe impossible things so that they can take in their stride the merely improbable things that they are ordinarily called upon to believe?

While I was writing this, the *Guardian* (July 29, 1991) fortuitously carried a beautiful example. It came in an interview with a rabbi undertaking the bizarre task of vetting the kosher-purity of food products right back to the ultimate origins of their minutest ingredients. He was currently agonizing over whether to go all the way to China to scrutinize the menthol that goes into cough sweets. ``Have you ever tried checking Chinese menthol... it was extremely difficult, especially since the first letter we sent received the reply in best Chinese English, `The product contains no kosher'... China has only recently started opening up to kosher investigators. The menthol should be OK, but you can never be absolutely sure unless you visit." These kosher investigators run a telephone hot-line on which up-to-the-minute red-alerts of suspicion are recorded against chocolate bars and cod-liver oil. The rabbi sighs that the green-inspired trend away from artificial colors and flavors ``makes life miserable in the kosher field because you have to follow all these things back." When the interviewer asks him why he bothers with this obviously pointless exercise, he makes it very clear that the point is precisely that there *is* no point:

> That most of the Kashrut laws are divine ordinances without reason given is 100 per cent the point. It is very easy not to murder people. Very easy. It is a little bit harder not to steal because one is tempted occasionally. So that is no great proof that I believe in God or am fulfilling His will. But, if He tells me not to have a cup of coffee with milk in it with my mincemeat and peaces at lunchtime, that is a test. The only reason I am doing that is because I have been told to so do. It is something difficult.

Helena Cronin has suggested to me that there may be an analogy here to Zahavi's handicap theory of sexual selection and the evolution of signals (Zahavi, 1975). Long unfashionable, even ridiculed (Dawkins, 1976), Zahavi's theory has recently been cleverly rehabilitated (Grafen, 1990 a, b) and is now taken seriously by evolutionary biologists (Dawkins, 1989). Zahavi suggests that peacocks, for instance, evolve their absurdly burdensome fans with their ridiculously conspicuous (to predators) colors, precisely *because* they are burdensome and dangerous, and therefore impressive to females. The peacock is, in effect, saying: ``Look how fit and strong I must be, since I can afford to carry around this preposterous tail."

To avoid misunderstanding of the subjective language in which Zahavi likes to make his points, I should add that the biologist's convention of personifying the unconscious actions of natural selection is taken for granted here. Grafen has translated the argument into an orthodox Darwinian mathematical model, and it works. No claim is here being made about the intentionality or awareness of peacocks and peahens. They can be as sphexish or as intentional as you please (Dennett, 1983, 1984). Moreover, Zahavi's theory is general enough not to depend upon a Darwinian underpinning. A flower advertising its nectar to a ``skeptical" bee could benefit from the Zahavi principle. But so could a human salesman seeking to impress a client.

The premise of Zahavi's idea is that natural selection will favor skepticism among females (or among recipients of advertising messages generally). The only way for a male (or any advertiser) to authenticate his boast of strength (quality, or whatever is is) is to prove that it is true by shouldering a truly costly handicap --- a handicap *that only a genuinely strong* (high quality, etc.) male could bear. It may be called the principle of costly authentication. And now to the point. Is it possible that some religious doctrines are favored not *in spite of* being ridiculous but precisely *because* they are ridiculous? Any wimp in religion could believe that bread *symbolically* represents the body of Christ, but it takes a real, red-blooded Catholic to believe something as daft as the transubstantiation. If you believe that you can believe anything, and (witness the story of Doubting Thomas) these people are trained to see that as a virtue.

Let us return to our list of symptoms that someone afflicted with the mental virus of faith, and its accompanying gang of secondary infections, may expect to experience.

4. The sufferer may find himself behaving intolerantly towards vectors of rival faiths, in extreme cases even killing them or advocating their deaths. He may be similarly violent in his disposition towards apostates (people who once held the faith but have renounced it); or towards heretics (people who espouse a different --- often, perhaps significantly, only very slightly different --- version of the faith). He may also feel hostile towards other modes of thought that are potentially inimical to his faith, such as the method of scientific reason which may function rather like a piece of anti-viral software.

The threat to kill the distinguished novelist Salman Rushdie is only the latest in a long line of sad examples. On the very day that I wrote this, the Japanese translator of *The Satanic Verses* was found murdered, a week after a near-fatal attack on the Italian translator of the same book. By the way, the apparently opposite symptom of ``sympathy'' for Muslim ``hurt,'' voiced by the Archbishop of Canterbury and other Christian leaders (verging, in the case of the Vatican, on outright criminal complicity) is, of course, a manifestation of the symptom we discussed earlier: the delusion that faith, however obnoxious its results, has to be respected simply because it *is* faith.

Murder is an extreme, of course. But there is an even more extreme symptom, and that is suicide in the militant service of a faith. Like a soldier ant programmed to sacrifice her life for germ-line copies of the genes that did the programming, a young Arab or Japanese [??!] is taught that to die in a holy war is the quickest way to heaven. Whether the leaders who exploit him really believe this does not diminish the brutal power that the ``suicide mission virus'' wields on behalf of the faith. Of course suicide, like murder, is a mixed blessing: would-be converts may be repelled, or may treat with contempt a faith that is perceived as insecure enough to need such tactics.

More obviously, if too many individuals sacrifice themselves the supply of believers could run low. This was true of a notorious example of faith-inspired suicide, though in this case it was not ``kamikaze'' death in battle. The Peoples' Temple sect became extinct when its leader, the Reverend Jim Jones, led the bulk of his followers from the United States to the Promised Land of ``Jonestown'' in the Guyanan jungle where he persuaded more than 900 of them, children first, to drink cyanide. The macabre affair was fully investigated by a team from the *San Francisco Chronicle* (Kilduff and Javers, 1978).

> Jones, ``the Father,'' had called his flock together and told them it was time to depart for heaven.
> ``We're going to meet,'' he promised, ``in another place.''
> The words kept coming over the camp's loudspeakers.
> ``There is great dignity in dying. It is a great demonstration for everyone to die.''

Incidentally, it does not escape the trained mind of the alert sociobiologist that Jones, within his sect in earlier days, ``proclaimed himself the only person permitted to have sex'' (presumably his partners were also permitted). ``A secretary would arrange for Jones's liaisons. She would call up and say, `Father hates to do this, but he has this tremendous urge and could you please...?' '' His victims were not only female. One 17-year-old male follower, from the days when Jones's community was still in San Francisco, told how he was taken for dirty weekends to a hotel where Jones received a ``minister's discount for Rev. Jim Jones and son.'' The same boy said: ``I was really in awe of him. He was more than a father. I would have killed my parents for him.'' What is remarkable about the Reverend Jim Jones is not his own self-serving behavior but the almost superhuman gullibility of his

followers. Given such prodigious credulity, can anyone doubt that human minds are ripe for malignant infection?

Admittedly, the Reverend Jones conned only a few thousand people. But his case is an extreme, the tip of an iceberg. The same eagerness to be conned by religious leaders is widespread. Most of us would have been prepared to bet that nobody could get away with going on television and saying, in all but so many words, ``Send me your money, so that I can use it to persuade other suckers to send me their money too." Yet today, in every major conurbation in the United States, you can find at least one television evangelist channel entirely devoted to this transparent confidence trick. And they get away with it in sackfuls. Faced with suckerdom on this awesome scale, it is hard not to feel a grudging sympathy with the shiny-suited conmen. Until you realize that not all the suckers are rich, and that it is often widows' mites on which the evangelists are growing fat. I have even heard one of them explicitly invoking the principle that I now identify with Zahavi's principle of costly authentication. God really appreciates a donation, he said with passionate sincerity, only when that donation is so large that it hurts. Elderly paupers were wheeled on to testify how much happier they felt since they had made over their little all to the Reverend whoever it was.

5. The patient may notice that the particular convictions that he holds, while having nothing to do with evidence, do seem to owe a great deal to epidemiology. Why, he may wonder, do I hold *this* set of convictions rather than *that* set? Is it because I surveyed all the world's faiths and chose the one whose claims seemed most convincing? Almost certainly not. If you have a faith, it is statistically overwhelmingly likely that it is the same faith as your parents and grandparents had. No doubt soaring cathedrals, stirring music, moving stories and parables, help a bit. But by far the most important variable determining your religion is the accident of birth. The convictions that you so passionately believe would have been a completely different, and largely contradictory, set of convictions, if only you had happened to be born in a different place. Epidemiology, not evidence.

6. If the patient is one of the rare exceptions who follows a different religion from his parents, the explanation may still be epidemiological. To be sure, it is *possible* that he dispassionately surveyed the world's faiths and chose the most convincing one. But it is statistically more probable that he has been exposed to a particularly potent infective agent --- a John Wesley, a Jim Jones or a St. Paul. Here we are talking about horizontal transmission, as in measles. Before, the epidemiology was that of vertical transmission, as in Huntington's Chorea.

7. The internal sensations of the patient may be startlingly reminiscent of those more ordinarily associated with sexual love. This is an extremely potent force in the brain, and it is not surprising that some viruses have evolved to exploit it. St. Teresa of Avila's famously orgasmic vision is too notorious to need quoting again. More seriously, and on a less crudely sensual plane, the philosophy Anthony Kenny provides moving testimony to the pure delight that awaits those that manage to believe in the mystery of transubstantiation. After describing his ordination as a Roman Catholic priest, empowered by laying on of hands to celebrate Mass, he goes on that he vividly recalls

> the exaltation of the first months during which I had the power to say Mass. Normally a slow and sluggish riser, I would leap early out of bed, fully awake and full of excitement at the thought of the momentous act I was privileged to perform. I rarely said the public Community Mass: most days I celebrated alone at a side altar with a junior member of the College to serve as acolyte and congregation. But that made no difference to the solemnity of the sacrifice or the validity of the consecration.
>
> It was touching the body of Christ, the closeness of the priest to Jesus, which most enthralled me. I would gaze on the Host after the words of consecration, soft-eyed like a lover looking

> into the eyes of his beloved... Those early days as a priest remain in my memory as days of fulfilment and tremulous happiness; something precious, and yet too fragile to last, like a romantic love-affair brought up short by the reality of an ill-assorted marriage. (Kenny, 1986, pp. 101-2)

Dr. Kenny is affectingly believable that it felt to him, as a young priest, as though he was in love with the consecrated host. What a brilliantly successful virus! On the same page, incidentally, Kenny also shows us that the virus is transmitted contagiously --- if not literally then at least in some sense --- from the palm of the infecting bishop's hand through the top of the new priest's head:

> If Catholic doctrine is true, every priest validly ordained derives his orders in an unbroken line of laying on of hands, through the bishop who ordains him, back to one of the twelve Apostles... there must be centuries-long, recorded chains of layings on of hands. It surprises me that priests never seem to trouble to trace their spiritual ancestry in this way, finding out who ordained their bishop, and who ordained him, and so on to Julius II or Celestine V or Hildebrand, or Gregory the Great, perhaps. (Kenny, 1986, p. 101)

It surprises me, too.

4 Is Science a Virus

No. Not unless all computer programs are viruses. Good, useful programs spread because people evaluate them, recommend them and pass them on. Computer viruses spread solely because they embody the coded instructions: ``Spread me.'' Scientific ideas, like all memes, are subject to a kind of natural selection, and this might look superficially virus-like. But the selective forces that scrutinize scientific ideas are not arbitrary and capricious. They are exacting, well-honed rules, and they do not favor pointless self-serving behavior. They favor all the virtues laid out in textbooks of standard methodology: testability, evidential support, precision, quantifiability, consistency, intersubjectivity, repeatability, universality, progressiveness, independence of cultural milieu, and so on. Faith spreads despite a total lack of every single one of these virtues.

You may find elements of epidemiology in the spread of scientific ideas, but it will be largely descriptive epidemiology. The rapid spread of a good idea through the scientific community may even look like a description of a measles epidemic. But when you examine the underlying reasons you find that they are good ones, satisfying the demanding standards of scientific method. In the history of the spread of faith you will find little else but epidemiology, and causal epidemiology at that. The reason why person A believes one thing and B believes another is simply and solely that A was born on one continent and B on another. Testability, evidential support and the rest aren't even remotely considered. For scientific belief, epidemiology merely comes along afterwards and describes the history of its acceptance. For religious belief, epidemiology is the root cause.

5 Epilogue

Happily, viruses don't win every time. Many children emerge unscathed from the worst that nuns and mullahs can throw at them. Anthony Kenny's own story has a happy ending. He eventually renounced his orders because he could no longer tolerate the obvious contradictions within Catholic belief, and he is now a highly respected scholar. But one cannot help remarking that it must be a powerful infection indeed that took a man of his wisdom and intelligence --- President of the British Academy, no less --- three decades to fight off. Am I unduly alarmist to fear for the soul of my six-year-old innocent?

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RICHARD DAWKINS'S EVOLUTIONRICHARD DAWKINS'S EVOLUTION

An irascible don becomes a surprising celebrity
By Ian Parker

From the Sept. 9 1996 issue of The New Yorker magazine.

RICHARD DAWKINS, arch-Darwinist, author of "The Selfish Gene", and Britain's village atheist, has a reputation for intellectual austerity and single-mindedness: he is a professor who will not stop professing. Because he knows the meaning of life (which is evolution by natural selection), and because others do not know it, or only half know it, or try willfully to mess with its simple, delicious truth, he promotes his subject in a way that-- if you wanted to drive him crazy--you could call evangelical. Besides writing his beautifully pellucid and best-selling books on Darwinian themes, Dawkins, who is a zoologist by training, is forever finding other opportunities to speak on behalf of evolution and on behalf of science. Now in his mid-fifties, he has become a familiar floppy-haired figure on television and in the newspapers, where he energetically scraps with bishops and charlatans. He recently argued, for example, that astrologers should be jailed, and he has complained warmly about what he alleges are one novelist's slurs on his profession. ("Sir," he wrote to the Daily Telegraph, "Pay Weldon's incoherent, petulant and nihilistic rant is the sort of thing I remember scribbling as a disgruntled teenager.") Dawkins regards it as his duty not to let things pass, or rest, and as he makes his slightly awkward--but still dashing--progress through the British media he occasionally encounters charges of arrogance and aggressiveness. It is not universally agreed that he is science's ideal public-relations director.

This, though, is now his job. Dawkins has been appointed the first Charles Simonyi Professor of Public Understanding of Science at Oxford University--Simonyi, the sponsor, being a soft-spoken Hungarian-born American made rich by long employment at Microsoft. Dawkins will now be expected to do more of what he has been doing: to write books, appear on television, and help counter what he calls "the stereo- type of scientists' being scruffy nerds with rows of pens in their top pocket"--an image that he regards, with a typical level of moderation, as "just about as wicked as racist stereotypes." Richard Dawkins has been made the new Oxford Professor of Being Richard Dawkins.

Because of all his media activity-- those bright, staring eyes on television-- it has sometimes been possible to for- get that Dawkins's reputation is founded on a remarkable writing achievement. Twenty years ago, with "The Selfish Gene" (1976), Dawkins managed to secure a wildly enthusiastic general readership for writing that was also of interest to his professional colleagues: he seduced two audiences at once. Biologists found themselves learning about their subject not from a paper in a learned journal but--as in an earlier tradition of scientific disclosure, one that includes Darvin's own work--from a book reviewed in the Sunday press. His later books, "The Blind Watchmaker" (1986) and "River Out of Eden" (1995), had a similar effect.

Like so much of Dawkins's enterprise, the inspiration for "The Selfish Gene" was rebuttal: the book was designed to banish an infuriatingly widespread popular misconception about evolution. The misconception was that Darwinian selection worked at the level of the group or the species, that it had something to do with the balance of nature. How else could one understand, for example, the evolution of apparent "altruism" in animal behavior? How could self-sacrifice, or niceness, ever have been favored by natural selection? There were answers to these questions, and they had been recently developed, in particular, by the evolutionary biologists W. D. Hamilton, now at Oxford, and George Williams, of the State University of New York at Stony Brook. But their answers were muted. Dawkins has written, "For me, their insight had a visionary quality. But I found their expressions of it too laconic, not full-throated enough. I was convinced that an amplified and developed version could make everything about life fall into place, in the heart as well as in the brain."

Essentially, their insight was that altruism in nature was a trick of the light. Once one understands that evolution works at the level of the gene--a process of gene survival, taking place (as Dawkins developed it) in bodies that the gene occupies and then discards--the problem of altruism begins to disappear. Evolution favors strategies that cause as many of an animal's genes as possible to survive--strategies that may not immediately appear to be evolutionarily sound. In the idea's simplest form, if an animal puts its life at risk for its offspring, it is preserving a creature - gene "vehicle," in Dawkins's language--half of whose genes are its own. This is a sensible, selfish strategy, despite the possible inconvenience of death. No one is being nice.

Starting from this point, "The Selfish Gene" took its reader into more complex areas of animal behavior, where more persuasion was needed--more mathematics, sometimes, and more daring logical journeys. Dawkins assumed no prior knowledge of the subject in his reader, yet was true to his science. He made occasional ventures into ambitious prose (genes "swarm in huge colonies, safe inside gigantic lumbering robots"), but mostly relied on sustained clarity, the taming of large numbers, and the judicious use of metaphor. The result was exhilarating. Upon the book's publication, the Times called it "the sort of popular science writing that makes the reader feel like a genius." Douglas Adams, a friend of Dawkins's and the author of "The Hitchhiker's Guide to the Galaxy," found the experience of reading it "one of those absolutely shocking moments of revelation when you understand that the world is fundamentally different from what you thought it was." He adds, "I'm hesitating to use the word, but it's almost like a religious experience."

Twenty Years later, Richard Dawkins finds himself something of a curiosity--a scientist with an honorary doctorate of letters, a philosopher with a CD-ROM deal, an ambassador who acknowledges that he is "not a diplomat," and a rather reticent man who in print is by turns flamboyantly scornful and boundlessly enthusiastic. I had been told that he "thinks scientifically and only scientifically"so when I recently visited him at his apartment in central Oxford--he has since moved house--I was surprised to find a great many wooden carrousel animals there, and a lot of cushions, which made a kind of sitcom chute from chair to floor. It was interesting, too, to note the cupboard by the living-room door, which had been lovingly hand-painted to represent the details of the life of Richard Dawkins: a childhood in Africa, a college room, a computer, a head of Charles Darwin, a young daughter "building castles in the air," and a panel suggesting an international reputation. The cupboard, I learned, was painted by Dawkins's mother, and was a gift to her son on his fiftieth birthday. (He is now fifty-five.) The horses and other large wooden animals were brought into the apartment by Lalla Ward, Dawkins's wife (his third), who inherited the collection. She used to be an actress, and it has caused some joy in the British press that Professor Dawkins is now married to a woman who played the part of an assistant to the television science-fiction character Doctor Who. (It's as if Stephen Jay Gould had married Lieutenant Uhura.)

Having finished with some students, Dawkins now appeared in the living room. A handsome matinee version of an Oxford don, he was wearing leather slippers and blue corduroy trousers. His manner managed to suggest both caution and assurance -- he has something of the air of a bullied schoolboy suddenly made prefect.

We talked about God, and other obstructions to an understanding of science. Dawkins complained of a "fairly common pattern in television news: right at the end a smile comes onto the face of the newsreader and this is the scientific joke--some scientist has proved that such and such is the case." He went on, "And it's clearly the bit of fun at the end, it's not serious at all. I want science to be taken seriously, because, after all, it's less ephemeral--it has a more eternal aspect than whatever the politics of the day might be, which, of course, gets the lead in the news."

Much of what is important to others is ephemeral to Dawkins. He shares his life with Darwin's idea--one that the philosopher Daniel Dennett, of Tufts, has called "the single best idea anyone has ever had." Dawkins does have tastes in art and in politics. He does have friends, and he has become more sociable in recent years. But his non-scientific tastes seem to shrink at the touch of science. He admires Bach's "St. Matthew Passion," but told me, "I really do feel what Bach might have done with some really decent inspiration, considering what he achieved with what he had." He was imagining "Evolution," the oratorio.

While we were talking at his apartment, the telephone rang often. Inevitably, Dawkins was one of the first to be featured in a jokey column in the Guardian called "Celebrity Scholars: A Cut- Out-and-Keep Guide to the Academics Whose Phones Are Always Ringing." He is not a geneticist, but because he once wrote a book that had the word "gene" in the title he is frequently asked to comment on contemporary genetic issues-- the discovery of genes "for" this or that, say, or the ethics of genetic engineering--and he ordinarily refers journalists to colleagues with the relevant expertise.

Dawkins is still most comfortable dealing with the pure, incontestable logic of Darwinian evolution. His fifth book, "Climbing Mount Improbable," will be published this month in the United States. With a fresh, unifying metaphor, Dawkins here continues his long-term project to make natural selection as Persuasive and comprehensible to others as it is to him. On the peaks of Mount Improbable, he explains, are to be found, say, a spiderweb and the camouflage of a stick insect. It would seem that one has to scale sheer cliffs of improbability to reach such complexity by natural selection. For one thing, natural selection does not Provide for developments that will turn out to be advantageous only after a million years of evolution. What use is a wing stub? What good is a half-evolved eye? But Dawkins points out the long, winding paths that lead to the summit of Mount Improbable--paths that have the gentlest of slopes and require no freakish upward leaps. He takes his reader up the slope from no eye to eye: a single (not entirely useless) photosensitive cell caused by genetic mutation, a group of such cells, a group arranged on a curve, and so forth. Dawkins knows that the length of this path will always daunt some readers. "Human brains," he writes, "though they sit atop one of its grandest peaks, were never designed to imagine anything as slow as the long march up Mount Improbable."

Dawkins took me to lunch in New College, where he has been a fellow for twenty-six years--"a bread-and-butter worker," he says. He and Lalla Ward and I sat at a long wooden table in a high-ceilinged room and ate soup with huge silver spoons, and between courses Lalla Ward set herself the task of making a rather introspective-looking college employee return her smile.

As a writer and broadcaster and propagandist, Dawkins has now left the laboratory far behind him. Wondering if this was a source of regret, I asked him if he would exchange what he had achieved for a more traditional scientific discovery. "I'd rather go to my grave having been Watson or Crick than having discovered a wonderful way of explaining things to people," he says. "But if the discovery you're talking about is an ordinary, run-of-the-mill discovery of the sort being made in laboratories around the world every day, you feel: Well, if I hadn't done this, somebody else would have, pretty soon. So if you have a gift for reaching hundreds of thousands-- millions--of people and enlightening them, I think doing that runs a close second to making a really great discovery like Watson and Crick."

After lunch, we walked back to the apartment, a hundred yards away, passing through a Chinese-style flock of student cyclists. In his cluttered living roorn, Dawkins talked about his past. His father, he said, worked in the British colonial service in Nyasaland, now Malawi, but with the outbreak of the Second World War he moved to Kenya to join the Allied forces. Richard was born in Nairobi, in 1941. In 1946, his father unexpectedly inherited a cousin's farm near Chipping Norton in Oxfordshire, and in 1949 the family returned to England. Dawkins drifted into zoology at Oxford, but he became fully engaged in it only when, some time after his arrival, the speculative nature of the subject revealed itself to him. "I think students of biochemistry, for example, before they can even start, probably have to get a lot of textbook knowledge under their belt," he says. "In animal behavior, you can jump straight into controversy and argument."

While still an undergraduate, Dawkins was taught by Niko Tinbergen, the Dutch-born animal behaviorist (and, later, Nobel Prize winner), who had him read doctoral theses in place of the standard texts. Dawkins remembers reading one thesis about two species of grasshopper, Chorthippus brunneus and Chorthippus biguttulus, that coexist on the European continent and look the same. "The only known difference between them is that they sing differently," he says. "They don't reproduce with each other, bemuse they sing differently. As a consequence of their not reproducing together, they're called two separate species--and they are. It' s not that they cannot breed but that they do not. Dawkins continues, "In the thesis that I read, the author found it was easy enough to fool them to mate with each other by playing them the song of their own species. And I got a feeling for how you design experiments when you're faced with a problem like this--and the intellectual importance of this first process in evolution. It happened to be grasshoppers, but it's the same process for all species on earth. They've all diverged from an ancestral species, and that process of divergence is the origin of species--it's the fundamental process that has given rise to all diversity on earth."

Dawkins graduated in 1962, and started immediately on his doctorate, for which he developed a mathematical model of decision-making in animals. In 1967, he married for the first time, and took up a post as an assistant professor of zoology at Berkeley. He became "a bit involved" in the dramas of the period, he told me. He and his wife marched a little, and worked on Eugene McCarthy's Presidential campaign. (Although colleagues today see Dawkins as apolitical, and enemies have sought to project a right-wing agenda onto his science, he has always voted on the left.) He returned to Oxford after two years and continued research into the mathematics of animal behavior, making much use of computers. In the winter of 1973-74, a coal miners' strike caused power cuts in Britain, preventing Dawkins from properly continuing his computer-driven research. He decided to write a book, which he finished a year later with "a tremendous momentum." The book was "The Selfish Gene," and its Preface starts, "This book should be read almost as though it were science fiction. It is designed to appeal to the imagination. But it is not science fiction: it is science."

When "The Selfish Gene" was published, in 1976, readers began writing to Dawkins that their lives had been changed; and most were pleased with the change. (Dawkins's peripheral theory of the self-replicating "meme," as a way of understanding the transmission of human culture and ideas--a meme for religion, or for baseball hats worn backward--began its impressive self-replicating career.) But Dawkins also caught the attention of his peers. Helena Crooning, a British philosopher of science, explains the response this way: "Very often in science one finds that there are ideas in the air, and lots of people hold them, but they don't even realize they hold them. The person who can crystallize them, and lay out not only the central idea but its implications for future scientific research can often make a tremendous contribution. And I think that's what 'The Selfish Gene' did. Lots of scientists, they'd been Darwinians all their lives, but they'd been inarticulate Darwinians. And now they really understood what was foundational to Darwinism and what was peripheral. And once you understand what is foundational, then you begin to deduce conclusions." In a variety of fields, Dawkins proved to be a catalyst.

In the twenty years following the publication of "The Selfish Gene"--years of teaching, fatherhood, wealth, and encroaching responsibilities as the British media's favorite scientist--Dawkins has published any number of papers and articles, and four more books, including "The Blind Watchmaker," a best-selling study of Darwinian design, written with the reach and elegance of "The Selfish Gene." On a rolling mass of ants in Panama, for instance:

> I never did see the queen, but somewhere inside that boiling ball she was the central data bank, the repository of the master DNA of the whole colony. Those gasping soldiers were prepared to die for the queen, not because they loved their mother, not because they had been drilled in the ideals of patriotism, but simply because their brains and their jaws were built by genes stamped from the master die carried in the queen herself. They behaved like brave soldiers because they had inherited the genes of a long line of ancestral queens whose lives, and whose genes, had been saved by soldiers as brave as themselves. My soldiers had inherited the same genes from the present queen as those old soldiers had inherited from the ancestral queens. My soldiers were guarding the master copies of the very instructions that made them do the guarding. They were guarding the wisdom of their ancestors.

These have been twenty Years of rising confidence and influence. "The world must be full of people who are biologists today rather than physicists because of Dawkins," John Maynard Smith, the senior British biologist, says. Outside the universities, in a climate newly friendly to accessible science books, Dawkins has become a literary fixture. Ravi Mirchandani, who published Dawkins at Viking, says, "If you're an intelligent reader, and you read certain literary novels that everybody has to read, along with seeing Tarantino movies, then reading Richard Dawkins has become part of your cultural baggage."

Dawkins's version of evolution also attracts critics, for it is dazzlingly digital. It features "robots" and "vehicles" and DNA, not flesh and fur; some evolutionary biologists regard him as a kind of reductionist fanatic -- an "ultra-Darwinist" who overplays the smooth mathematical progress of natural selection and its relevance to an animal's every characteristic, every nook and cranny. A biting review of "The Selfish Gene" by Richard Lewontin, of Harvard, published in Nature, talked of "Dawkins's discovery of vulgar Darwinism." It was an error of "new Panglossians," Lewontin wrote, to think that "all describable behavior must be the direct product of natural selection." (This is the sin of excessive "adaptationism.") In the continuing debate, Maynard Smith, George Williams, and W. D. Hamilton are in one camp; in the other are Steven Rose, Lewontin, Leon Kamin (these three collaborated on a book called "Not in Our Genes"), and Stephen Jay Gould, the man who is in many ways Dawkins's American counterpart. Dawkins and Gould have undertaken the same project--eliminating the barrier between the practice of science and its communication to a wider audience. And they stand shoulder to shoulder against the creationists. But they would not want to be stuck in the same elevator.

In 1979, Gould and Lewontin wrote a famous paper called "The Spandrels of San Marco and the Panglossian Paradigm: A Critique of the Adaptationist Programme," which argued that natural selection can be limited by or can be a by-product of an animal's architecture in the way that the spandrels of St. Mark's in Venice (described by the authors as "the tapering triangular spaces formed by the intersection of two rounded arches at right angles") are "necessary architectural by-products of mounting a dome on rounded arches," and were not designed to be painted upon, although that might be how it looks. Gould also contests the evolutionary "gradualism" of the Dawkins camp, and promotes "punctuated equilibrium"-- the theory that evolution goes by fits and starts. Gould's opponents suspect him of exaggerating his differences with contemporary Darwinism: they want him to know that one can make a stir in science without making a revolution. Dawkins said, "I really want to say that there are no major disagreements." But he added, "I think the tendency of American intellectuals to learn their evolution from him is unfortunate, and that's putting it mildly."

Earlier this year, Richard Dawkins took part in a public debate in a hall on the edge of Regent's Park, in central London. The debate, which was organized by the Oxford-based Jewish society L'Chaim, set Dawkins against the very distinguished Jewish scholar Rabbi Adin Steinsaltz. The question to be debated was "Does God exist?" In the lobby, tempers were fraying as it became clear that the event had been greatly oversubscribed. Three hundred people were sent away, and one could hear cries of "I've got a ticket! I'm not moving!" and so on

The two speakers took their places on the wooden stage of the main hall, and were introduced with some old Woody Allen jokes. Dawkins then spoke of design, and of the miserable logic of trying to use a God-who must be complex--as an explanation of the existence of complex things. By contrast, he said, "Darwinian evolution explains complicated things in terms of simple things." In reply, Rabbi Steinsaltz made an occasionally witty but rather digressive speech, in which he always seemed to lose interest in a point just before he made it. He talked of giraffs, though it was not entirely clear what we were to think of them. ("'You know these animals. Beautiful eyes.") Dawkins found himself arguing with a theist of his imagination rather than with the man to his right, who was frustratingly unresponsive to his favorite evolutionary sound bites. ("Not a single one of your ancestors died young. They all copulated at least once.") One member of the society told me that Dawkins was significantly gentler than he used to be at these meetings: he used to go into "a frenzy of savage attack, saying all religious people are delusional, weak-minded." That night, he seemed to win the debate, speaking in his curious shy, confident way.

This is the kind of event that presents the new Professor of Public Understanding with a problem: he has become wary of the atheist's reputation suffocating the evolutionist's. And yet he cares deeply about religion; he is sure that it matters. "It's important to recognize that religion isn't something sealed off in a watertight compartment," he says. "Religions do make claims about the universe--the same kinds of claims that scientists make, except they're usually false." Richard Dawkins is not a great one for cultural relativism. He says, "The proof of the pudding is: When you actually fly to Your international conference of cultural anthropologists, do you go on a magic carpet or do you go on a Boeing 747?"

In Dawkins's kitchen in Oxford, a headline had been torn out of a newspaper and stuck on the wall, in an office-humor sort of way It read "THE PROBLEMS OF DAWKINISM." The main problem, which is experienced particularly by those who have not read his books, remains one of tone. Douglas Adams says, laughing, "Richard once made a rather wonderful remark to me. He said something like 'I really don't think I'm arrogant, but I do get impatient with people who don't share with me the same humility in front of the facts.' " The glory of Darwinism fills Dawkins's brain, but it drops out of the brains of others, or is nudged out by God or Freud or football or Uranus moving into Aquarius, and Dawkins finds this maddening. "It is almost as if the human brain were specifically designed to misunderstand Darwinism, and to find it hard to believe," he has written. Dawkins does not seem to have developed this point, and he sometimes allows disdain or mockery to take the place of a clearer understanding of it--the evolution of resistance to evolution. Even the admiring Charles

Simonyi, who funds the job for which Richard Dawkins is so precisely suited, and so precisely unsuited, says he has urged Dawkins to "tame his militancy."
"I'm a friendly enough sort of chap," Dawkins told me. "I'm not a hostile person to meet. But I think it's important to realize that when two opposite points of view are expressed with equal intensity, the truth does not necessarily lie exactly halfway between them. It is possible for one side to be simply wrong." *

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What Makes a Suicide Bomber a Suicide Bomber ?

Richard Dawkins attempts an answer. Please read and reflect.
Shuddha

Richard Dawkins is professor of the public understanding of science, University of Oxford, and author of The Selfish Gene, The Blind Watchmaker, and Unweaving the Rainbow.

Richard Dawkins
Guardian

Saturday September 15, 2001

A guided missile corrects its trajectory as it flies, homing in, say, on the heat of a jet plane's exhaust. A great improvement on a simple ballistic shell, it still cannot discriminate particular targets. It could not zero in on a designated New York skyscraper if launched from as far away as Boston.

That is precisely what a modern "smart missile" can do. Computer miniaturisation has advanced to the point where one of today's smart missiles could be programmed with an image of the Manhattan skyline together with instructions to home in on the north tower of the World Trade Centre. Smart missiles of this sophistication are possessed by the United States, as we learned in the Gulf war, but they are economically beyond ordinary terrorists and scientifically beyond theocratic governments. Might there be a cheaper and easier alternative?

In the second world war, before electronics became cheap and miniature, the psychologist BF Skinner did some research on pigeon-guided missiles. The pigeon was to sit in a tiny cockpit, having previously been trained to peck keys in such a way as to keep a designated target in the centre of a screen. In the missile, the target would be for real.

The principle worked, although it was never put into practice by the US authorities. Even factoring in the costs of training them, pigeons are cheaper and lighter than computers of comparable effectiveness. Their feats in Skinner's boxes suggest that a pigeon, after a regimen of training with colour slides, really could guide a missile to a distinctive landmark at the southern end of Manhattan island. The pigeon has no idea that it is guiding a missile. It just keeps on pecking at those two tall rectangles on the screen, from time to time a food reward drops out of the dispenser, and this goes on until... oblivion.

Pigeons may be cheap and disposable as on-board guidance systems, but there's no escaping the cost of the missile itself. And no such missile large enough to do much damage could penetrate US air space without being intercepted. What is needed is a missile that is not recognised for what it is until too late. Something like a large civilian airliner, carrying the innocuous markings of a well-known carrier and a great deal of fuel. That's the easy part. But how do you smuggle on board the necessary guidance system? You can hardly expect the pilots to surrender the left-hand seat to a pigeon or a computer.

How about using humans as on-board guidance systems, instead of pigeons? Humans are at least as numerous as pigeons, their brains are not significantly costlier than pigeon brains, and for many tasks they are actually superior. Humans have a proven track record in taking over planes by the use of threats, which work because the legitimate pilots value their own lives and those of their passengers.

The natural assumption that the hijacker ultimately values his own life too, and will act rationally to preserve it, leads air crews and ground staff to make calculated decisions that would not work with guidance modules lacking a sense of self-preservation. If your plane is being hijacked by an armed man who, though prepared to take risks, presumably wants to go on living, there is room for bargaining. A rational pilot complies with the hijacker's wishes, gets the plane down on the ground, has hot food sent in for the passengers and leaves the negotiations to people trained to negotiate.

The problem with the human guidance system is precisely this. Unlike the pigeon version, it knows that a successful mission culminates in its own destruction. Could we develop a biological guidance system with the compliance and dispensability of a pigeon but with a man's resourcefulness and ability to infiltrate plausibly? What we need, in a nutshell, is a human who doesn't mind being blown up. He'd make the perfect on-board guidance system. But suicide enthusiasts are hard to find. Even terminal cancer patients might lose their nerve when the crash was actually looming.

Could we get some otherwise normal humans and somehow persuade them that they are not going to die as a consequence of flying a plane smack into a skyscraper? If only! Nobody is that stupid, but how about this - it's a long shot, but it just might work. Given that they are certainly going to die, couldn't we sucker them into believing that they are going to come to life again afterwards? Don't be daft! No, listen, it might work. Offer them a fast track to a Great Oasis in the Sky, cooled by everlasting fountains. Harps and wings wouldn't appeal to the sort of young men we need, so tell them there's a special martyr's reward of 72 virgin brides, guaranteed eager and exclusive.

Would they fall for it? Yes, testosterone-sodden young men too unattractive to get a woman in this world might be desperate enough to go for 72 private virgins in the next.

It's a tall story, but worth a try. You'd have to get them young, though. Feed them a complete and self-consistent background mythology to make the big lie sound plausible when it comes. Give them a holy book and make them learn it by heart. Do you know, I really think it might work. As luck would have it, we have just the thing to hand: a ready-made system of mind-control which has been honed over centuries, handed down through generations. Millions of people have been brought up in it. It is called religion and, for reasons which one day we may understand, most people fall for it (nowhere more so than America itself, though the irony passes unnoticed). Now all we need is to round up a few of these faith-heads and give them flying lessons.

Facetious? Trivialising an unspeakable evil? That is the exact opposite of my intention, which is deadly serious and prompted by deep grief and fierce anger. I am trying to call attention to the elephant in the room that everybody is too polite - or too devout - to notice: religion, and specifically the devaluing effect that religion has on human life. I don't mean devaluing the life of others (though it can do that too), but devaluing one's own life. Religion teaches the dangerous nonsense that death is not the end.

If death is final, a rational agent can be expected to value his life highly and be reluctant to risk it. This makes the world a safer place, just as a plane is safer if its hijacker wants to survive. At the other extreme, if a significant number of people convince themselves, or are convinced by their priests, that a martyr's death is equivalent to pressing the hyperspace button and zooming through a wormhole to another universe, it can make the world a very dangerous place. Especially if they also believe that that other universe is a paradisical escape from the tribulations of the real world. Top it off with sincerely believed, if ludicrous and degrading to women, sexual promises, and is it any wonder that naive and frustrated young men are clamouring to be selected for suicide missions?

There is no doubt that the afterlife-obsessed suicidal brain really is a weapon of immense power and danger. It is comparable to a smart missile, and its guidance system is in many respects superior to the most sophisticated electronic brain that money can buy. Yet to a cynical government, organisation, or priesthood, it is very very cheap.

Our leaders have described the recent atrocity with the customary cliche: mindless cowardice. "Mindless" may be a suitable word for the vandalising of a telephone box. It is not helpful for understanding what hit New York on September 11. Those people were not mindless and they were certainly not cowards. On the contrary, they had sufficiently effective minds braced with an insane courage, and it would pay us mightily to understand where that courage came from.

It came from religion. Religion is also, of course, the underlying source of the divisiveness in the Middle East which motivated the use of this deadly weapon in the first place. But that is another story and not my concern here. My concern here is with the weapon itself. To fill a world with religion, or religions of the Abrahamic kind, is like littering the streets with loaded guns. Do not be surprised if they are used.

The Evolved Imagination: Animals as models of their world

by Richard Dawkins

In the pioneering days of radio, my grandfather's job was to lecture to young engineers who were joining Marconi's company. To illustrate that any complex wave form can be broken down into summed simple waves of different frequencies (important in both radio and acoustics), he took wheels of different diameters and attached them with pistons to a clothesline. When the wheels went round, the clothesline was jerked up and down, causing waves of movement to snake along it. The wriggling clothesline was a model of a radio wave, giving the students a more vivid picture of wave summation than mathematical equations could ever have done.

This was my first exposure to models in the ordinary scientific sense: a model resembles the real thing in some important respects, although it may not necessarily look, to the human eye, like a replica of the real thing. A child's train set is a model, but so also is a railway timetable. Engineers build airplane models for testing in wind tunnels; weather forecasters make use of very elaborate, dynamic computer models of the earth's weather.

Biologists, too, use models to express what they think is going on inside organisms and in ecosystems. But I want to say something altogether more radical. An animal is a model. Any organism is a model of the world in which it lives. One way to understand this is to imagine a zoologist presented with the body of an animal she has never seen before. If allowed to examine and dissect the body in sufficient detail, a good zoologist should be able to reconstruct almost everything about the world in which the animal lived. To be more precise, she would be reconstructing the worlds in which the animal's ancestors lived. I say this because an animal can never be strictly adapted to its present environment. It is always adapted to a sum of past environments in which its ancestors survived. More strictly still, the sum is a weighted sum, with the weights diminishing as we go back in time.

All these claims rest upon the Darwinian assumption that animal bodies are largely shaped by natural selection. If Darwin's theory is correct, an animal is the inheritor of attributes that enabled its ancestors to be ancestors. If they hadn't had those successful attributes, they would have been not ancestors but the childless rivals of ancestors.

So, what are the attributes that make for success as an ancestor, the attributes that we should expect to find in the body of our animal when we inspect it? The answer is anything that helps the individual animal to survive and reproduce in its own environment—not just one or two attributes, but hundreds, thousands of them. This is why, if you present an animal's body, even a new species previously unknown to science, to a knowledgeable zoologist, she should be able to "read' its body and tell you what kind of environment it inhabited: desert, rain forest, arctic tundra, temperate woodland, or coral reef. She should also be able to tell you, by reading its teeth and its guts, what it fed on. Flat, millstone teeth indicate a herbivore; sharp, shearing teeth, a carnivore. Long intestines with complicated blind alleys indicate a herbivore; short, simple guts suggest a carnivore. By reading the animal's feet and its eyes and other sense organs, the zoologist should be able to tell how it found its food. By reading its stripes or flashes, its horns, antlers, or crests, she should be able to tell something about its social and sex life.

But zoological science has a long way to go. By reading the body of a newly discovered species, we can now come up with only a rough verdict about its probable habitat and way of life—rough in the same way as a pre-computer weather forecast was rough. The zoology of the future will computerize many more measurements of the anatomy and chemistry of the animal being read. More importantly, it will not take the teeth, guts, and chemistry of the stomach separately. It will perfect techniques of combining sources of information and analyzing their interactions, resulting in inferences of enormous power The computer, incorporating every thing that is known about the body of the strange animal, will construct a model of the animal's world to rival any model of die earth's weather. This. it seems to me, is tantamount to saying that the animal, any animal, is a model of its own world or the world of its ancestors. And its genes are a coded description of the worlds in which its ancestors survived.

In a few cases, an animal's body is a model of its world in the literal sense. A stick insect lives in a world of twigs, and its body is a precise replica of a twig. A fawn's pelage is a model of the dappled pattern of sunlight filtered through trees onto the woodland floor. A peppered moth is a model of lichen on the tree bark that is the moth's world when at rest. But models, as we have seen, do not stop at replicas.

Models can be static or dynamic, and sometimes both. A railway timetable is a static model, while a weather model in a computer is dynamic: it is continually—in advanced systems continuously—being updated by new readings from around the world. (Even with the help of sophisticated computers and updated information from satellites, balloons, ships, planes, and weather stations, accurate forecasting is possible only for a few days ahead, at best.) Some aspects of an animal's body are a static model of its world—the millstone slab of a horse's tooth, for instance. Other aspects are dynamic. Sometimes the change is slow. A Dartmoor pony grows a shaggy coat in winter and sheds it in summer. The zoologist presented with a pony's pelt can read not only the kind of place it inhabited but also the season of the year in which it was caught. Many animals of high northern latitudes, such as arctic foxes, snowshoe hares, and ptarmigans, are white in winter and brownish in summer.

But animals are dynamic on much faster time scales as well—time scales of seconds and fractions of seconds. These are the time scales of behavior, which can be seen as high-speed dynamic modeling of the environment. Think of a herring gull adroitly riding a sea cliff's upcurrents. It may not be flapping its wings, but this doesn't mean that its wing muscles are idle. They, along with the tail muscles, are constantly making tiny adjustments, sensitively fine-tuning the bird's flight surfaces to every nuance, every eddy, of the air around it. If we fed information about the state of all these muscles into a computer, from moment to moment the computer could in principle reconstruct every detail of the air currents through which the bird was gliding. It would assume that the bird was well designed to glide, and on that assumption construct a model of the air around the bird. Again, it would be a model in the same sense as the weather forecaster's. Both are continuously revised by new data. Both can be extrapolated to predict the future. The weather model predicts tomorrow's weather; the gull model could "advise" the bird on the anticipatory adjustments that it should make to its wing and tail muscles in order to glide on into the next second.

Even if no human programmer has yet constructed a computer model that could advise gulls on how to adjust their wing and tail muscles, just such a model is almost certainly being run continuously in the brain of the gull and of every other bird in flight. Similar models, preprogrammed in outline by genes and past experience, and continuously updated by new sense data from millisecond to millisecond, are running inside the skull of every swimming fish, every galloping horse, every echo-ranging bat.

I should not wish, by using the metaphor of the computer, to imply that brains work like modern digital electronic computers. They probably don't. The principle of getting information about the real world by simulating it internally is what I want to emphasize, and the digital electronic computer happens to be a familiar and powerful tool for simulation. But there are other conceivable tools that are not digital and not electronic, and the brain might well resemble them more. Before digital computers became readily available, engineers used a variety of devices to simulate reality. My grandfather's clothesline was a simple example. Other such "analogue" devices were, and sometimes still are, used to solve serious mathematical problems. A mathematical function, for example, can be represented as a curve of a particular shape.

As recently as World War II, differential equations were solved by elaborate mechanical analogue computers consisting of concatenations of mathematically curved cams and rods sliding over one another. Even today, the simplest way of solving that mathematician's chestnut—the "traveling salesman" problem (planning an optimal route for a salesman who has to visit a particular list of cities)—is by knotting bits of string together.

The same is true of some other optimization problems. The brain obviously doesn't tie knots in string, but the psychologist and philosopher Kenneth Craik and the biologist John Maynard Smith have conjectured (not in these words) that brain models have more in common with knotted string than with digital computers. For our purposes here, it doesn't matter. It is sufficient that the brain makes simulation models of the outside world. I think in terms of digital electronic computers because I am familiar with them, but neither their digitalness nor their electronicness is important to the analogy.

Can an animal's mental model of its world free-run into the future and so simulate future events, as does the computer model of the world's weather? Suppose we set up an experiment. Find a steep cliff in a mountainous area of Ethiopia inhabited by hamadryas baboons and place a plank so that it sticks out over the edge of the precipice, with a banana on its far tip. The center of gravity of the plank is just on the safe side of the edge, so that it does not topple into the gorge below, but if a monkey were to venture out to the end of the plank, it would be enough to tip the balance. Now we hide and watch what the monkeys do. They are clearly interested in the banana, but they do not venture out along the plank to get it. Why not?

We can imagine three stories, any of which might be true, to account, for the baboons' prudence. In all three stories the cautious behavior results from a kind of trial and error, but of three different kinds. According to the first story, the baboons have an "instinctive" fear of precipitous heights. This fear has been built into their brains directly by natural selection. Their ancestors' contemporaries that did not possess a genetic tendency to fear cliffs failed to become ancestors because they got killed. Consequently, since modem baboons are all descended, by definition, from successful ancestors, they have inherited the genetic predisposition to fear cliffs. There is indeed some experimental evidence that the newly born young of a variety of species have an innate fear of heights. In "visual-cliff" experiments, a sheet of glass lies on a table and projects over the edge. Newborn animals are then placed on the glass near the edge, to see whether they shy away from the edge or are indifferent to it. The first story, then, involves trial and error of the crudest and most drastic kind: Darwinian natural selection dicing with ancestral life and death. We can call this the Ancestral Fear story.

The second story talks about the past experiences of the individual baboons. Each young baboon, as it grows up, experiences falling. Most likely, it will have enough encounters with small cliffs to learn that falls can be painful. (If it falls down a huge cliff, of course, the experience is its last.) Pain, in trial-and-error learning, is the analogue of death in natural selection. Natural selection has built brains with the capacity to experience as pain those very sensations that, in a stronger dose, would lead to the animal's death. Pain is not only the analogue of death; it is also a kind of symbolic substitute for death if we think in terms of an analogy between learning and natural selection. Baboons build up in their brains, through experience of the pain of falling down small cliffs (perhaps through experience that the bigger the cliff, the worse the pain), a tendency to avoid cliffs. This is the second story, the Painful Experience story, of how the baboons have come to resist their natural tendency to rush out along the plank to seize the banana.

The third story is the one this is all leading up to. According to this story, each baboon has a model of the situation in its head, a virtual reality simulation of the cliff, the plank, and the banana, and it can run the simulation program on into the future. Just as the arcade computer simulates the racing car passing a tree, the baboon's computer simulates his body advancing toward the banana, the model plank teetering, then toppling and crashing into the simulated abyss. The brain simulates it all and evaluates the results of the computer run. And that, according to our Simulated Experience story, is why the baboon doesn't venture out in reality. It is a trial-and-error story, just like the Ancestral Fear and Painful Experience stories, but this time it is trial and error in the head, not in reality. Obviously, trial and error in the head, if you have a powerful enough computer there to do it, is preferable to trial and error in earnest.

Now, as you read these stories, I have little doubt that you had an imaginary picture of the scene. You "saw" the cliff, you "saw" the plank, and you "saw" the baboons. The details of all our imaginary pictures are, no doubt, very different. But we all set up a simulation of the scene, which was adequate the task of predicting a baboon's future. We all know, from the inside, what it is like to run a simulation of the world in our heads. We call it imagination, and we use it all the time to steer our decisions in wise and prudent directions.

The experiment with the baboons and the banana has not been done. If it were, could the results tell us which of our three stories was true, or whether the truth was some combination? If the Painful Experience story were true, we should be able to find out by looking at the behavior of young or inexperienced baboons. One who had been sheltered all his life from falls should prove fearless when eventually confronted with an edge. If such a naive baboon turned out in fact to be fearful, this would still leave the other two stories open. He have inherited ancestral fear or he might have a vivid imagination. We could try to decide the issue by a further experiment. Say we place a heavy rock on the near end of the plank. Now we humans, at least, can see from our own mental simulation that it is safe to venture along the plank: the rock is obviously a secure counterbalance.

What would the baboons do? I don't know. But I do know that, however certain I was from my mental model that the rock would be a staunch counterweight, I wouldn't go out along the plank, not for a crock of gold. I just can't take heights. The Ancestral Fear story sounds pretty plausible to me. What is more, so powerful is this fear that it enters into my Simulated Experience. When I imagine the scene, I experience a frisson of fear up my spine, however vividly I am able to simulate a ten-ton rock firmly clamped down on the plank. Since I know that all three stories are true for me, I could easily believe the same of baboons.

The imagination, the capacity to simulate things that are not (yet) in the world, is a natural progression from the capacity to simulate things that are in the world. The weather model is continually updated by information from weather ships and weather stations. To this extent it is a simulation of conditions as they really are. Whether or not it was originally designed to run on into the future, its ability to do so, to simulate things not only as they are but as they may turn out to be, is a natural, almost inevitable consequence of its being a model at all. An economist's computer model of the economy of Britain is, so far, a model of things as they are and have been. The program hardly needs to be modified to take that extra step into the simulated future, to project probable future trends in the gross national product, the currency, and the balance of payments.

So it was in the evolution of nervous systems. Natural selection built in the capacity to simulate the world as it is because this was necessary in order to perceive the world. You cannot see that two-dimensional patterns of lines on two retinas amount to a single solid cube unless you simulate, in your brain, a model of the cube. Having built in the capacity to simulate models of thing as they are, natural selection found that it was but a short step to simulate things as they are not quite yet—to simulate the future. This turned out to have valuable consequences, for it enabled animals to benefit from "experience," not trial-and-error experience in their own past or in the life and death experience of their ancestors, but vicarious experience in the safe interior of the skull.

And once natural selection had built brains capable of simulating slight departures from reality into the imagined future, a further capacity automatically flowered. Now it was but another short step to the wilder reaches of imagination revealed in dreams and in art, an escape from mundane reality that has no obvious limits.

[Richard Dawkins, "The Evolved Imagination: Animals as models of their world," In Natural History magazine, 104 (September 1995): 8-11, 22-23.]

Interview with Richard DawkinsInterview with Richard Dawkins

Preliminaries

Between 13 August 1995 and 26 August 1995 Steven Carr posted the transcript of a 1994 Channel-4 (U.K.) interview with biologist Richard Dawkins to the Usenet newsgroup alt.atheism.moderated. With Steven's permission, I have made the postings available here. I have combined Steven's multiple postings into one document, made some formatting changes, deleted Steven's comments, fixed typos, and changed some British spellings to American ones.

In my opinion, Dawkins was as provocative and clear in his statements as ever, and I cannot but agree with what he says. Not surprisingly, the series of postings generated a mass of crackpot attempts at rationalizations of the concept of God with science and the Universe. In spite of the moderation, the signal-to-noise ratio in alt.atheism.moderated quickly plummeted to zero.

Feedback: If you have questions or comments regarding the HTML formatting, please send them to me at krishna_kunchith@hotmail.com. If you have any questions about the interview or transcription, direct them at Steven Carr. If you have comments about the contents of the interview, mail Richard Dawkins at Oxford.

Enjoy.

Krishna.

Introduction

Channel 4 in the UK ran a half-hour series of interviews in 1994 called The Vision Thing. Various people with different beliefs were interviewed by Sheena McDonald, a respected TV journalist. The only atheist viewpoint was put by Richard Dawkins on 15 Aug. 1994.

The views expressed do not necessarily agree with mine. This is not just the usual disclaimer.

Note that throughout the interview Sheena McDonald had a half-smile on her face as if to say "Well, these are strange opinions but I suppose I'll have to give them a hearing". She was though, as always, scrupulously fair.

At the time of the interview Richard Dawkins was reader in zoology at the University of Oxford. He is now Professor of Public Understanding of Science at Oxford. He currently has 3 of the top 10 best selling science books in Britain.

Steven Carr.

Interview: Sheena McDonald and Richard Dawkins

McDonald's intro: Imagine no religion! Even non-believers recognize the shock value of John Lennon's lyric. A godless universe is still a shocking idea in most parts of the world. But one English zoologist crusades for his vision of a

world of truth, a world without religion, which he says is the enemy of truth, a world which understands the true meaning of life. He's called himself a scientific zealot. In London I met Richard Dawkins.
McDonald: Richard Dawkins, you have a vision of the world---this world free of lies, not the little lies that we protect ourselves with, but what you would see as the big lie, which is that God or some omnipotent creator made and oversees the world. Now, a lot of people are looking for meaning in the world, a lot of them find it through faith. So what's attractive about your godless world, what's beautiful---why would anyone want to live in your world?
Dawkins: The world and the universe is an extremely beautiful place, and the more we understand about it the more beautiful does it appear. It is an immensely exciting experience to be born in the world, born in the universe, and look around you and realize that before you die you have the opportunity of understanding an immense amount about that world and about that universe and about life and about why we're here. We have the opportunity of understanding far, far more than any of our predecessors ever. That is such an exciting possibility, it would be such a shame to blow it and end your life not having understood what there is to understand.
McDonald: Right, well, let's maximize this opportunity. Paint the world, describe the opportunity that too many of use---you will probably say most of us---are not exploiting to appreciate the world and to understand the world.
Dawkins: Well, suppose you look at an animal such as a human or a hedgehog or a bat, and you really want to understand how it works. The scientific way of understanding how it works would be to treat it rather as an engineer would treat a machine. So if an engineer was handed this television camera that engineer would get a screwdriver out, take it to bits, perhaps try to work out a circuit diagram and try to work out what this thing did, what it was good for, how it works, would explain the functioning of the whole machine in terms of the bits, in terms of the parts.
Then the engineer would probably want to know how it came to be where it was, what's the history of it---was it put together in a factory? Was it sort of suddenly just gelled together spontaneously? Now those are the sorts of questions that a scientist would ask about a bat or a hedgehog or a human, and we've got a long way to go, but a great deal of progress has been made. We really do understand a lot about how we and rats and pigeons work.
I've spoken only of the mechanism of a living thing. There's a whole other set of questions about the history of living things, because each living thing comes into the world through being born or hatched, so you have to ask, where did it get its structure from? It got it largely from its genes. Where do the genes come from? From the parents, the grand-parents, the great-grand parents. You go on back through the history, back through countless generations of history, through fish ancestors, through worm-like ancestors, through protozoa-like ancestors, to bacteria-like ancestors.
McDonald: But the end point of this process would simply be an understanding of the physical world.
Dawkins: What else is there?

McDonald: But to accept your vision, one has to reject what many people hold very dear and close, which is faith. Now, why is faith, why is religious faith incompatible with your vision?
Dawkins: Well, faith as I understand it---you wouldn't bother to use the word faith unless it was being contrasted with some other means of knowing something. So faith to me means knowing something just because you know it's true, rather than because you have seen any evidence that it's true.
McDonald: But if I say I believe in God, you cannot disprove the existence of God.
Dawkins: No, and the virtue of using evidence is precisely that we can come to an agreement about it. But if you listen to two people who are arguing about something, and they each of them have passionate faith that they're right, but they believe different things---they belong to different religions, different faiths, there is nothing they can do to settle their disagreement short of shooting each other, which is what they very often actually do.
McDonald: If religion is an obstacle to understanding what you're saying, why is it getting it wrong?
Dawkins: A creator who created the universe or set up the laws of physics so that life would evolve or who actually supervised the evolution of life, or anything like that, would have to be some sort of super-intelligence, some sort of mega-mind. That mega-mind would have had to be present right at the start of the universe. The whole message of evolution is that complexity and intelligence and all the things that would go with being a creative force come late, they come as a consequence of hundreds of millions of years of natural selection. There was no intelligence early on in the universe. Intelligence arose, it's arisen here, maybe it's arisen on lots of other places in the universe. Maybe somewhere in some other galaxy there is a super-intelligence so colossal that from our point of view it would be a god. But it cannot have been the sort of God that we need to explain the origin of the universe, because it cannot have been there that early.
McDonald: So religion is peddling a fundamental untruth.
Dawkins: Well, I think it is yes.
McDonald: And there is no possibility of there being something beyond our knowing, beyond your ability as a scientist, zoologist, to [...]
Dawkins: No, that's quite different. I think there's every possibility that there might be something beyond our knowing. All I've said is that I don't think there is any intelligence or any creativity or any purposiveness before the first few hundred million years that the universe has been in existence. So I don't think it's helpful to equate that which we don't understand with God in any sense that is already understood in the existing religions.
The gods that are already understood in existing religions are all thoroughly documented. They do things like forgive sins and impregnate virgins, and they do all sorts of rather ordinary, mundane, human kinds of things. That has nothing whatever to do with the high-flown profound difficulties that science may yet face in understanding the deep problems of the universe.
McDonald: Now a lot of people find great comfort from religion. Not everybody is

as you are---well-favored, handsome, wealthy, with a good job, happy family life. I mean, your life is good---not everybody's life is good, and religion brings them comfort.
Dawkins: There are all sorts of things that would be comforting. I expect an injection of morphine would be comforting---it might be more comforting, for all I know. But to say that something is comforting is not to say that it's true.
McDonald: You have rejected religion, and you have written about and posited your own answers to the fundamental questions of life, which are---very crudely, that we and hedgehogs and bats and trees and geckos are driven by genetic and non-genetic replicators. Now instantly I want to know, what does that mean?
Dawkins: Replicators are things that have copies of themselves made. It's a very, very powerful---its' hard to realize what a powerful thing it was when the first self-replicating entity came into the world. Nowadays the most important self-replicating entities we know are DNA molecules; the original ones probably weren't DNA molecules, but they did something similar. Once you've got self-replicating entities---things that make copies of themselves---you get a population of them.
McDonald: In that very raw description that makes us---what makes us us? We're no more than collections of inherited genes each fighting to make its way by the survival of the fittest.
Dawkins: Yes, if you ask me as a poet to say, how do I react to the idea of being a vehicle for DNA? It doesn't sound very romantic, does it? It doesn't sound the sort of vision of life that a poet would have; and I'm quite happy, quite ready to admit that when I'm not thinking about science I'm thinking in a very different way.
It is a very helpful insight to say we are vehicles for our DNA, we are hosts for DNA parasites which are our genes. Those are insights which help us to understand an aspect of life. But it's emotive to say, that's all there is to it, we might as well give up going to Shakespeare plays and give up listening to music and things, because that's got nothing to do with it. That's an entirely different subject.
McDonald: Let's talk about listening to music and going to Shakespeare plays. Now, you coined a word to describe all these various activities which are not genetically driven, and that word is 'meme' and again this is a replicating process.
Dawkins: Yes, there are cultural entities which replicate in something like the same way as DNA does. The spread of the habit of wearing a baseball hat backwards is something that has spread around the Western world like an epidemic. It's like a smallpox epidemic. You could actually do epidemiology on the reverse baseball hat. It rises to a peak, plateaus and I sincerely hope it will die down soon.
McDonald: What about voting Labour?
Dawkins: Well, you can make---one can take more serious things like that. In a way, I'd rather not get into that, because I think there are better reasons for voting Labour than just slavish imitation of what other people do. Wearing a reverse baseball hat---as far as I know, there is no good reason for that.

One does it because one sees one's friends do or, and one thinks it looks cool, and that's all. So that really is like a measles epidemic, it really does spread from brain to brain like a virus.
McDonald: So voting intentions you wouldn't put into that bracket. What about religious practices?
Dawkins: Well, that's a better example. It doesn't spread, on the whole, in a horizontal way, like a measles epidemic. It spreads in a vertical way down the generations. But that kind of thing, I think, spreads down the generations because children at a certain age are very vulnerable to suggestion.
They tend to believe what they're told, and there are very good reasons for that. It is easy to see in a Darwinian explanation why children should be equipped with brains that believe what adults tell them. After all, they have to learn a language, and learn a lot else from adults. Why wouldn't they believe it if they're told that they have to pray in a certain way? But in particular---let's just rephrase that---if they're told that not only do they have to behave in such a way, but when they grow up it is their duty to pass on the same message to their children.
Now, once you've got that little recipe, that really is a recipe for passing on and on down the generations. It doesn't matter how silly the original instruction is, if you tell it with sufficient conviction to sufficiently young and gullible children such that when they grow up they will pass it on to their children, then it will pass on and it will pass on and it will spread and that could be sufficient explanation.
McDonald: But religion is a very successful meme. I mean, in your own structures the genes that survive---the ones with the most selfish and successful genes presumably have some merit. Now if religion is a meme which has survived over thousands and thousands of years, is it not possible that there is some intrinsic merit in that?
Dawkins: Yes, there is merit in it. If you ask the question, why does any replicating entity survive over the years and the generations, it is because it has merit. But merit to a replicator just means that it's good at replicating.
The rabies virus has considerable merit, and the AIDS virus has enormous merit.
These things spread very successfully, and natural selection has built into them extremely effective methods of spreading. In the case of the rabies virus it causes its victims to foam at the mouth, and the virus is actually spread in saliva. It causes them to bite and to become aggressive, so they tend to bite other animals, and the saliva gets into them and it gets passed on. This is a very, very successful virus. It has very considerable merit.
In a way the whole message of the meme and gene idea is that merit is defined as goodness at getting itself spread around, goodness at self-replication. That's of course very different from merit as we humans might judge it.
McDonald: You've chosen an analogy there for religion which a lot of them would find rather hurtful---that it's like an AIDS virus, like a rabies virus.
Dawkins: I think it's a very good analogy. I'm sorry if it's hurtful. I'm trying to explain why these things spread; and I think it's like a chain letter. It is the same kind of stick and carrot. It's not, probably, deliberately thought out.

I could write on a piece of paper "Make two copies of this paper and pass them to friends". I could give it to you. You would read it and make two copies and pass them, and they would make 2 copies and it becomes 4 copies, 8, 16 copies. Pretty soon the whole world would be knee-deep in paper. But of course there has to be some sort of inducement, so I would have to add something like this "If you do not make 2 copies of this bit of paper and pass it on, you will have bad luck, or you will go to hell, or some dreadful misfortune will befall you".

I think if we start with a chain letter and then say, well, the chain letter principle is too simple in itself, but if we then sort of build upon the chain letter principle and look upon more and more sophisticated inducements to pass on the message, we shall have a successful explanation.

McDonald: But that's all it can be, I mean, sophisticated inducements or threats. I was only bothered that a successful meme may invoke something which has not yet been found in your universe by your methods.

Dawkins: The sophisticated inducements can include the B Minor Mass and the St. Matthew Passion. I mean, they're pretty good stuff. They're very sophisticated and very, very beautiful---stained glass windows, Chartres Cathedral, they work and no wonder they work. I mean they're beautifully done, beautifully crafted. But I think what you're asking is, does the success of religion down the centuries imply that there must be some truth in its claims? I don't think that is necessary at all, because I think there are plenty of other good explanations which do a better job.

McDonald: Does it exasperate you that people find more pleasure and inspiration in Chartres or Beethoven or indeed great mosques than they do in the anatomy of a lizard?

Dawkins: No, not at all. I mean, I think that great artistic experiences---I don't want to downplay them in any way. I think they are very, very great experiences, and scientific understanding is on a par with them.

McDonald: And yet, these great artistic achievements have been impelled by untruths.

Dawkins: Just think how much greater they would have been if they had been impelled by truth.

McDonald: But can the anatomy of a lizard provoke a great choral symphony?

Dawkins: By calling it the anatomy of a lizard, you, as it were, play for laughs. But if you put it another way---let's say, does geological time or does the evolution of life on earth, could that be the inspiration for a great symphony? Well, of course, it could. It would be hard to imagine a more colossal inspiration for a great piece of music or poetry than 2,000 million years of slow, gradual evolutionary change.

McDonald: But ultimately, there's no point beyond the personal celebration of each life, as far as you're able to. We hope that we're not born into a famine queue in central Africa. But that's not sufficient for people. Maybe they want [...]

Dawkins: Look, it may not be [...]

McDonald: But tough, you say [...]

Dawkins:Tough, yes. I don't want to sound callous. I mean, even if I have nothing to offer, that doesn't matter, because that still doesn't mean that what anybody else has to offer therefore has to be true.
McDonald: Indeed, but you care about it.
Dawkins: Yes, I do want to offer something. I just wanted to give as a preamble the point that there may be a vacuum which is left. If religion goes, there may well be a vacuum in important ways in people's psychology, in people's happiness, and I don't claim to be able to fill that vacuum, and that is not what I want to claim to be able to do. I want to find out what's true.
Now, as for what I might have to offer, I've tried to convey the excitement, the exhilaration of getting as complete a picture of the world and the universe in which you live as possible. You have the power to make a pretty good model of the universe in which you live. It's going to be temporary, you're going to die, but it would be the best way you could spend your time in the universe, to understand why you're there and place as accurate model of the universe as you can inside your head. That's what I would like to encourage people to try to do. I think it's an immensely fulfilling thing to do.
McDonald: And that will be a better world?
Dawkins: It will certainly be a truer world. I mean, people would have a truer view of the world. I think it would probably be a better world. I think people would be less ready to fight each other because so much of the motivation for fighting would have been removed. I think it would be a better world. It would be a better world in the sense that people would be more fulfilled in having a proper understanding of the world instead of a superstitious understanding.
McDonald: So here we are, in your truer world---except we're not, because for the reasons of juvenile gullibility you suggested the religion meme will continue to replicate itself around the world. For ever will it, or will we ever come to your world?
Dawkins: I suspect for a very long time. I don't know about for ever, whatever for ever is. I mean, I think religion has got an awful long time to go yet, certainly in some parts of the world. I find that a rather depressing prospect, but it is probably true.
McDonald: Isn't that to an extent because you've said yourself, what you have to say may not fill the vacuum which would be left if religion were discarded?
Dawkins: I feel no vacuum. I mean, I feel very happy, very fulfilled. I love my life and I love all sorts of aspects of it which have nothing to do with my science. So I don't have a vacuum. I don't feel cold and bleak. I don't think the world is a cold and bleak place. I think the world is a lovely and a friendly place and I enjoy being in it.
McDonald: Do you think about death?
Dawkins: Yes. I mean, it's something which is going to happen to all of us and [...]
McDonald: How do you prepare for death in a world where there isn't a god?
Dawkins: You prepare for it by facing up to the truth, which is that life is what we have and so we had better live our life to the full while we have it, because there is nothing after it. We are very lucky accidents or at least each

one of us is---if we hadn't been here, someone else would have been. I take all this to reinforce my view that I am fantastically lucky to be here and so are you, and we ought to use our brief time in the sunlight to maximum effect by trying to understand things and get as full a vision of the world and life as our brains allow us to, which is pretty full.

McDonald: And that is the first duty, right, responsibility, pleasure of man and woman. Christians would say "love God, love your neighbor". You would say "try to understand".

Dawkins: Well, I wouldn't wish to downplay love your neighbor. It would be rather sad if we didn't do that. But, having agreed that we should love our neighbor and all the other things that are embraced by that wee phrase, I think that, yes, understand, understand is a pretty good commandment.

(End of interview)

Sheena McDonald's wrap-up to camera: Richard Dawkins celebrates life before death with infectious enthusiasm. He rejects life after death with---for many---uncomfortable enthusiasm. In doing so he shows the courage of a true zealot, to go on preaching in the face of continuing resistance to a godless universe. It remains to be seen whether the Dawkins meme, his vision of truth, will replicate with the success that the prophets, priests, popes and gurus have enjoyed.

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Richard Dawkins: The man who knows the meaning of life

He opened up the frontiers of science to a wide public and married one of Dr Who's assistants. But, as Colin Hughes finds, while banging the drum for his version of 'the truth' about evolution, he drowns out views that differ from his own.

Saturday October 3, 1998

People frequently ask Richard Dawkins: "Why do you bother getting up in the morning if the meaning of life boils down to such a cruel pitiless fact, that we exist merely to help replicate a string of molecules?" As he puts it: "They say to me, how can you bear to be alive if everything is so cold and empty and pointless? Well, at an academic level I think it is - but that doesn't mean you can live your life like that. One answer is that I feel privileged to be allowed to understand why the world exists, and why I exist, and I want to share it with other people." Dawkins' new book, Unweaving The Rainbow, to be published later this month, is billed as an attempt to answer the 'why get up?' question, and indeed the first couple of chapters do just that, arguing that scientific discovery has a compelling, almost poetic impact on the imagination.

"It's about why I think science is one of the supreme things that makes life worth living," he says. "We are fantastically privileged to exist at all, but then we also have the privilege of understanding this beautiful world in which we find ourselves. that should make us all the more eager to soak up as much as we possibly can of understanding our world and our place in it before we die."

Or, as the book puts it: "Mysteries do not lose their poetry when solved. Quite the contrary: the solution often turns out more beautiful than the puzzle... " In making this case Dawkins betrays all his rhetorical genius, and his faintly naive sense of everyday folk. He brilliantly berates those of us (all of us, probably) who succumb to the "anaesthetic of familiarity," by which he means allowing yourself to stop noticing that the world around you is coruscating with wonder. But he also shows how little he understands common humanity: "Just think," he enthuses, "instead of reading the football results you can read about distant galaxies!" As if one precludes the other.

When he expands in this way, hands clasped, leaning forward on a folding chair on the paved patio of his Oxford garden, he assumes a sparkling-eyed, boyish eagerness. This is his most appealing mode, in which it is easy to warm to his articulate, infectious absorption in his life's work - explaining and elaborating the potent truth of evolutionary theory. But it is also clear that he is capable of a dry chill, of a wincing, suck-toothed disdain. So far from suffering fools, he is capable of pouring a withering stream of scorn on the kind of woolly thinkers and wet-minded pseudo-religious fantasists who form the large phalanx of his opponents.

In fact, most of the new book is less about how science provides a meaning to life than about how Dawkins himself finds purpose in the continuing battle for the supremacy of searing scientific truth.

Even when you're on his side, the tone sometimes feels unduly severe.

There lies the Dawkins paradox. Beginning with his 1976 book The Selfish Gene, which argues that life is simply a means of propagating DNA, with every creature ruthlessly determined to continue its own line, he has probably done more to focus lay intelligence on scientific truth in the past quarter century than any other individual, including Stephen Hawking, principally by writing with a compelling first-person directness. yet he is also capable of being peculiarly unengaging in person.

The man who writes and lectures so vividly that his images and ideas are indelibly printed on your mind, can be strangely remote. Why? Probably it's the combination of that maddening Oxford air of high intellectual superiority (in his case justified - he's a fellow of New College), attached to an acute personal sensitivity. However, people who know him say all this comes with a leavening of humour. John Krebs, head of the NERC and an old friend, says: "Some people see Richard as a relentlessly serious individual, without a lighter side. Actually he has a very well-developed sense of the ridiculous." He is one of those fortunate men in whom, despite catkin-white eyebrows and the greying hair of a 56-year-old, you can still see the face of his boyhood. He was born into a family of colonial forest officers, his grandfather in Burma, his father in Nyasaland - now Malawi - and then Kenya, which is where Clinton Richard was born in 1941, during the darkest days of the war. But if he modelled himself on any of them it was his uncle Colyear, a statistical biologist and fellow of St John's, Oxford, about whose lecturing Dawkins rhapsodizes: "I suppose I still subconsciously try to emulate his teaching style. He was quite stunning." When Richard was only seven his father unexpectedly inherited a farm near Chipping Norton and the family returned to England: not long after, Richard was sent to board at Oundle. Unusual among public schools at that time, Oundle had a self-consciously practical bent: boys were required to spend time making things in workshops.

You might expect in that atmosphere that Dawkins would storm at the natural sciences, replete with his family's long interest. In fact, he says, he felt no special enthusiasm at school for biology, and merely 'drifted' into that stream because of his family background. His biology teacher, Ioan Thomas, recalls: "He wasn't by any means a committed natural historian - it was rather a matter of wanting to be open-minded." The enthusiasm Dawkins really picked up at school was computing, and he recognises that his life-long fascination with programming has played a huge part in shaping his thought. The way computers think and operate is one of his dominant metaphors, and metaphor is his favourite tool.

The questioning mind was certainly there: according to Thomas, the boy was "alert and thoughtful enough" to realise that what he was learning in biology didn't tally with what he was being asked to imbibe at two compulsory Christian services every week. "I remember his housemaster ringing me up one Sunday evening, and I told him that 'requiring that young man to attend chapel every Sunday is doing him positive harm'." And though he didn't stand out as academically shining bright, he clearly had the determination to succeed: after A levels, preparing for Oxford entrance, Thomas told Dawkins' parents that their boy "might just scrape Oxford, but wasn't good enough to get into Balliol at this rate". Dawkins' 'rate' immediately shifted up a gear and he was accepted by Balliol. Even at Oxford, though, there is a sense that he slipped into studying zoology, rather than being captivated. But it was a lucky step since the subject of animal behaviour threw him directly into his preferred habitat of speculative debate as opposed to laboratory experiment. He has, as he puts it, done his "fair share" of hard observation and experiment in his time.

But it's not the sight of teeming tropical jungle life or the wonderful weirdness of observed creatures that really grips him: "What really fascinates me is that they are all - plants twining round the trees, ants on the jungle floor, extraordinary salamanders - in their immensely complicated, enmeshed ways doing the same fundamental thing, which is propagating genes. It's the joy of understanding that appeals to me." The crucial relationship at Oxford was with Niko Tinbergen, Dutch-born Nobel prize-winning ethologist, of whom Dawkins says he felt in awe: "He loved my essays, and said flattering things about them, and that encouraged me to do a DPhil, clearly a turning point in my life." One of Tinbergen's central contentions was that animal and plant bodies could be viewed as 'survival machines', an idea that played a key part in fertilising Dawkins' selfish gene metaphor. But his post-doctoral work set off in what he calls "mathematical directions" - actually constructing a model for interpreting decision-making in animals.

George Barlow, of the University of California, Berkeley, spotted Dawkins at an international ethological conference in Rennes in

1967. "I was stunned by the stellar performance of someone so new on the scene, and relatively unknown. He had the audience in the palm of his hand. His topic? A relatively esoteric problem of how best to determine the colour a chick preferred." The highlight, Barlow recalls, was Dawkins' demonstration of a little box chicken he had built, which electronically duplicated the way the chick distributed pecks. "He brought the house down. I figured if he could make such an abstract and potentially deadly dull question so fascinating, he was certainly going to make his mark." Barlow later that year offered him a job as an assistant professor. He tells how Dawkins, in his acceptance letter, pointed out tongue in cheek that his "great-great something or other was General Clinton who fought against the Americans in the War of Independence, and he hoped we could forgive him." Just before leaving for Berkeley Dawkins married for the first time, a researcher called Marian Stamp, so when they arrived in California (where the Barlows put them up initially) they were on honeymoon. Barlow recalls putting them in a corridor bedroom through which his daughters trooped at all hours: "Some honeymoon!" The young couple became close to Barlow's children: "It was Richard's first exposure to peanut butter and jelly sandwiches - he had the girls in stitches because he ate them with a knife and fork." Barlow's recollections also illustrate the kind of youthful intensity of the couple - how they set their clocks ahead an hour so that they would get up earlier and be more productive, and how Marian loaded Richard's razor with different blades in a blind experiment so that he could find out which brand was best without fear of bias. The picture is of a young, reserved man with a somewhat eccentric and slightly unworldly sense of humour, but also of phenomenal curiosity and intelligence, growing up in that late 1960s era of Buckminster Fuller radicalism and Vietnam protest.
When he first published The Selfish Gene its message was widely misunderstood to imply that human society is driven solely by the 'me' motive. Dawkins found himself interpreted far and wide as the intellectual apologist for self-seeking, anti-society Thatcherite economics. In fact his political instincts have always been on the liberal left: he worked for Eugene McCarthy's presidential campaign, and joined anti-war marches.
He came home from Berkeley to New College, Oxford, a hard-working, committed and quietly ambitious scientist. Dawkins resumed his connection with Tinbergen, along with his computational approach to ethology. But then a vengeful technician sabotaged the computer records where Dawkins worked, making it temporarily hard for his research to continue. Then the country was forced into a three-day working week: the consequent 1974 power cuts left Dawkins unable to keep up his lab work. He started using the free time to write a book about neo-Darwinist ideas which was eventually published as The

Selfish Gene.
Even now, re-reading it a quarter century on, the book's immediacy is still gripping. No wonder so many fellow scientists are sneeringly jealous of Dawkins' writing talent. It is bland and inadequate to say merely that he can express complex abstract ideas in easily comprehensible language. Dawkins is far more potent than your everyday populariser. The book's polemical spell is mesmeric: the prose compels not only your attention, but also your acceptance. It is little wonder that Selfish Gene changed the way people think. It even changed many lives.
Ever since, of course, the great debate in the scientific world has been over how original the ideas really were. Even at the time prominent supporters of Dawkins, such as John Maynard Smith and Bill Hamilton, said that Dawkins' drawing together of ideas - like those developed by the British geneticists RA Fisher and JBS Haldane, and the American, Sewall Wright, since the 1920s and 1930s - led to original strands of thought, even in the Selfish Gene itself. But there were vicious critics, notably the Harvard scientist Richard Lewontin who reviewed the book scathingly in Nature.
John Krebs says: "Richard has interpreted and explained the ideas of neo-Darwinism with unique clarity, force and elegance. He has also explored the consequences of extending these ideas into new domains. Often the creators of the core ideas will themselves read Richard's work and say, 'Gosh, I never thought of it in those terms', or 'I hadn't realised that one could deduce such and such from my starting point'." Professor Pat Bateson, provost of King's College, Cambridge, who has known Dawkins since their early twenties, has absolutely no doubt that his image for thinking about evolution really helped several generations of students and the lay public to think about evolution: "You can take any young biologist and they will say when they read Dawkins it all suddenly became clear. His extraordinary ability to use metaphors really brought the subject alive for people." But Bateson thinks any portrayal of Dawkins as "merely a populariser" is worse than cheap, it is actually wrong. "There are aspects of his thinking which go much deeper," he argues. The final chapter of Dawkins' book The Extended Phenotype contains what Bateson regards as a "very interesting and original" speculation about how development itself might have evolved - one of the trickier issues in evolution theory.
Michael Rodgers, who edited Selfish Gene and most of Dawkins' subsequent books, says while Dawkins has a sense of humour and a nice infectious laugh he is "an evangelist, and takes that side very seriously". After the book was published letters poured in from readers thanking Dawkins for opening their minds. Some told Rodgers that they had decided to study biology in consequence.
"One academic I talked to at the time criticised it for being too

well written. Students, he said, would be seduced, ditch their critical faculties and believe it presented 'the truth'." The irony, of course, is that Dawkins frankly does regard his understanding of natural selection as the truth - a truth that is "beautiful in its power".

Rodgers says: "Thirty years ago there was in the UK a real anti-science feeling, and it was respectable to parade an ignorance of science. That's changed, and I think Richard can be credited in no small measure with helping to bring that about." Dawkins makes absolutely no attempt to claim a grand achievement for himself. "The image of the selfish gene enabled me to understand the ideas, and that helped other people understand it too. I was saying no more than RA Fisher said in 1930." The modesty is both beguiling and infuriating. Partly it's just the way Oxford dons are, always countering a speculative query with the apology that they don't really know enough about the subject, when in fact they are 100 times better placed to discuss it than you are. It's not as disconcerting, though, as his bristling discomfort with difficult personal questions, which leaves you feeling that he struggles to grasp how other people view him. He is sharply defensive about some areas of his private life - areas which probably say more about him than anything he has ever written or said about himself.

In his book Climbing Mount Improbable, Dawkins recalls how he asked his six-year-old daughter, Juliet, what flowers were for. She answered, not unreasonably given her age, that the purpose of flowers was to give us beautiful things to look at, and honey for the bees. Gently, her dad disabused her.

Since so much of the delight in reading Dawkins is his thrill at uncovering the elaborate wonders of the natural world (unravelling the byzantine relationships between figs and their co-dependent wasps, for instance), you wonder how having a child has affected him - perhaps enabling him to see the world through a child's eyes? After all, his Royal Institution Faraday lectures for children were a great success, captivating a young audience as expertly as a stage conjuror might.

Instead of leading him into reflections on children and childhood, the question makes Dawkins tense up and withdraw: "I don't see that much of her, to my enormous regret. I only see her alternate weekends. You're so busy trying to make sure the weekend is a success, and that things don't go badly wrong, you don't have the luxury of exploring those other things." Anyone who lives apart from their children can recognise those difficult feelings. And it is also clear that Dawkins adores his only daughter.

About Lalla Ward, his third wife, Dawkins talks very happily indeed. She is the pretty former Dr Who sidekick Romana, but he hastens to say that she played more serious parts too, such as Ophelia in the

BBC's Hamlet. They met at a party held by Douglas Adams, author of The Hitchhiker's Guide to the Galaxy (which Dawkins loves) and a former Dr Who scriptwriter ("apparently his scripts were a cut above the others", says Dawkins, loyally). Lalla has since drawn excellent sketches for Dawkins' books.

Their home is just off the Banbury Road, in one of those huge old north Oxford houses next to the university parks, that you approach by one of two gaps in a wall, scrunching over gravel through which bits of grass grow tastefully but not too tidily around the edges.

To the right of the front door is Dawkins' office, usually inhabited by his assistant Ingrid, and a neat cluster of desks, PCs, printers and fax machines (everything to do with Dawkins is orderly). To the left is a long sitting room decorated by an electric piano on one corner (for Juliet to practice on), and Lalla's famed collection of fairground carousel horses, inherited from her mother.

Straight through and you walk into a large garden that would naturally be described as 'country', except that you're within sprinting distance from Oxford city centre. There's an indoor pool on one flank of the paved patio, and a vast slab of Purbeck stone propped up as an outside table on the other. "It's the same stone as they used for those heads around the Sheldonian theatre," says Dawkins.

Life is obviously now very comfortable, presumably in part because of the endowment from Charles Simonyi, one of Bill Gates' Microsoft millionaires, who funded the chair of professor for the public understanding of science that Dawkins is the first to hold. The new job led him to write Unweaving the Rainbow. He felt obliged to lay out his credo, his reason for believing it important that non-specialists should have at least some grasp of what's known at the frontiers of science. But Dawkins carries so much baggage that it is impossible for him to write such a book without resuming the fierce diatribes against religion, or sardonic attacks on other evolutionists who he regards as misguided, which in great measure now define his public persona.

One of those battles is with Stephen Jay Gould, a warm and appealing American paleontologist who also writes with great panache about evolution, and whose books have hugely influenced both lay and scientific readers in the United States.

Many of Dawkins' friends think he should just let this argument lie, since, in their view, the difference is a relatively minor one centering on whether evolution occurred in a smooth and steady progression, or underwent periods of accelerated development interspersed with periods of comparative stagnation.

Dawkins accepts it is perfectly possible that evolutionary change moved faster at some times than others, but is driven to steely outrage by what he sees as the manipulation of fossil evidence to suggest that vast numbers of species sprang into existence in tiny periods of geological time.

Why does it bother Dawkins so much? Because, whereas many scientists are content for lay people merely to have a rough grasp of what's going on, Dawkins wants them to get it right. The truth matters. He cannot bear to see flabby writing (which is essentially what he accuses Gould of) lead people into a misunderstanding.

John Krebs says: "I think this is a lot of fuss about not very much. Although it is sometimes presented in the press as a fundamental disagreement about the role of Darwinism in evolution, I don't think it is anything of the sort. It is partly a matter of emphasis, and partly a matter of salesmen staking out their territories." But it matters to Dawkins because he fears that Gould gives people an excuse to doubt natural selection altogether: if species can suddenly spring into existence, perhaps God gave evolution a helping hand? No extrapolation could be better calculated to drive Dawkins into a fury of contention. At one point Dawkins said although Gould was a good writer "that makes him all the more damaging - people assume his ideas are scientific truths". Gould struck back: "It is not just a question of Dawkins' argument being inadequate. It's wrong." Many of Dawkins' friends worry that his militant atheism and evangelistic fervour damage not only his personal reputation, but also the scientific cause.

As Rodgers says: "Some academics, not necessarily believers, think it does harm to the public image of science when he suggests that science has, or will get, all the answers." But if that's what he passionately believes, surely that's what he should passionately say? George Barlow says that among the creationists of America (where some school boards came close to banning Darwinian textbooks), Dawkins is regarded as 'evil incarnate'. Dawkins talks more warily about religion now, which suggests that he has taken his friends' concern to heart. But it's more a question of his struggling (against his nature) to be more diplomatic in framing his argument. He hasn't changed his mind at all. In conversation, he emphasises how much he enjoys engaging with clerics on the issue of creation and natural selection, and makes it plain that the argument seems to him immensely important.

Asked if he finds believers actively objectionable, he says: "Not at all. In fact I find them interesting, because at least they're asking the right questions. They're just coming up with the wrong answer. What I can't understand is those people, particularly scientists, who say that you can put these matters into two separate compartments." The sharp logician in him won't allow a fellow scientist to believe two contradictory truths: he gave me a recent survey showing that scientists who believe in God are not only small in number but also dwindling, a discovery which hugely satisfies him.

If you were brave you'd speculate that middle age and his third wife have tempered Dawkins' demeanour. He delights in music, literature, all the normal pleasures of cultured humanity. The new book contains more personal reference than all his other books put together. But it also gives the strong impression that this intensely sensitive man is reacting to the long-standing criticism that he has only ever had one thing to say: after all, every book until now has been an elaboration on the The Selfish Gene's original theme. So now, at 57, he's exploring somewhere else.

But why should the criticism bother him? He may only ever have written about one question but of all questions it's arguably the biggest and the best - what are we, why are we here, where did we come from? Dawkins deeply believes he found the answer 30 years ago, and he wants you to know that it awes him still.

The only problem with this laudable ambition is that his talent does not really lie in winning people over with charm; it lies in cutting through comfortable illusions to expose the motiveless reality of life. And the plain fact is, some people cannot bear too much reality.

Unweaving The Rainbow is published by Penguin Press/Allen Lane on October 22, price £20.

Useful links

The Third Culture

When Religion Steps on Science's Turf by Richard Dawkins

Richard Dimbleby Lecture given by Richard Dawkins in 1996

The world of Richard Dawkins (unofficial website)