Communicating Biological Sciences

Ethical and Metaphorical Dimensions

Edited by

Brigitte Nerlich
Richard Elliott
Brendon Larson

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Contents

l ist of Figures and t ables

f igures

t ables

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n otes on the Contributors

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a ndrew Balmer's research interests centre on the scientific development and social, legal and philosophical implications of emerging technologies that claim to significantly reconfigure conceptualisations of life, self, truth and justice. He uses theoretical positions developed within cultural studies and science and technology studies (STS). His PhD at the Institute for Science and Society (University of Nottingham) critically examined the use of functional magnetic resonance imaging as a lie detector. h e has published on the concept of lying, the use of the polygraph machine in the context of sexual offending, the political construction of the human/animal binary in palaeontology and the emergence of ethical issues in synthetic biology.

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f iona f ox is the founding director of the Science Media Centre (London), She has a degree in Journalism and 15 years' experience in media relations. She held the position of Senior Press Officer for the Equal Opportunities Commission for six years, followed by two years running the media operation at the n ational Council for o ne Parent Families. a total change of environment followed as Fiona became h ead of m edia at Ca Fo D, one of the u K's leading aid agencies. She founded the Jubilee 2000 press group, which helped to force serious t hird World issues onto the media and political agendas. Fiona is an experienced public speaker and a trained journalist who has written extensively for newspapers and publications, authored several policy papers and contributed to books on humanitarian aid.

Sheila Jasanoff is Pforzheimer Professor of Science and t echnology Studies at h arvard u niversity's John F. Kennedy School of g overnment. She has held academic positions at Cornell, Yale, o xford, and Kyoto. a t Cornell, she founded and chaired the Department of Science and t echnology Studies. She has also been a l everhulme Visiting Professor at Cambridge, Fellow at the Berlin institute for Advanced Study, and Resident Scholar at the Rockefeller Foundation's Bellagio study center. h er research concerns the role of science and technology in the law, politics, and public policy of modern democracies, with a particular focus on the challenges of globalization. She has written and lectured widely on problems of environmental regulation, risk management, and biotechnology in the United States, Europe, and India. Her books include *Controlling Chemicals* (1985), *The Fifth Branch* (1990), *Science at the Bar* (1995), and *Designs on Nature* (2005). Jasanoff has served on the Board of Directors of the a merican a ssociation for the a dvancement of Science and as President of the Society for Social Studies of Science.

Iina h ellsten currently works as Assistant Professor at the Athena Institute (Amsterdam), which specialises in research on innovation and communication in health and life sciences. Her work has focused on the politics of metaphors in public controversies on emerging biosciences such as cloning, genomics, gm foods, the Human Genome Project, stem cell research, bird flu and synthetic biology. She has published in journals including *Science Communication*, *New Genetics & Society*, *Scientometrics*, *New Media & Society*, *Metaphor and Symbol*, *Journal of Computer Mediated Communication*, *Information Research*, *Internet Research*, *Science as Culture* and *International Journal of Modern Physics C: Computational Physics*.

Camille h erreman has an educational background in the natural sciences and now studies politics at the u niversity of n ottingham where she edits the student journal *Cease.r e.* In 2008 she worked as an intern at the Institute of Science and Society, and is now writing her undergraduate dissertation on the effects of new forms of media on political activism and organisation.

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t oby Murcott trained as a research biochemist before realising that he was better at talking about science than doing it, prompting a move into journalism. He spent seven years at the BBC r adio Science u nit, including time as BBC World Service Science Correspondent. He also managed to squeeze in being Science Editor for *Maxim* magazine. t oby followed this with a two year stint as e ditor of digital satellite science channel *Einstein TV*. h e currently writes regularly for *The Times*, produces *Home Planet* for BBC r adio 4, consults on science communication for a number of different organisations and teaches science journalism.

Brigitte Nerlich is Professor of Science, l anguage, and Society at the institute for Science and Society, at the u niversity of n ottingham. She studied French and philosophy in g ermany, where she did her PhD in French linguistics. a fter three years as a Junior r esearch Fellow in general linguistics at the u niversity of o xford she moved to Nottingham, where she worked in the departments of linguistics and psychology before moving to the institute. h er current research focuses on the cultural and political contexts in which metaphors and other linguistic devices are used in public and scientific debates about biotechnology, nanotechnology, health and illness and climate change. She has written books and articles on the history of linguistics, historical semantics, pragmatics and cognitive linguistics and, more recently, the social study of science and technology.

Matthew C. Nisbet is Professor in the School of Communication at a merican u niversity at Washington, DC, where his research focuses on the intersections between science, media, and politics. h e is a social scientist who studies strategic communication in policy-making and public affairs. His current work focuses on controversies surrounding science, the environment, and public health. in this research, Nisbet examines how journalists cover policy debates, how strategists try to mould public opinion, and how citizens make sense of complex and politically charged issues. h e has analyzed a wide range of debates including those over stem cell research, global warming, intelligent design, food biotechnology, nanotechnology, and hurricanes.

t im Radford was born in n ew Zealand in 1940, and became a newspaper reporter at 16. He worked for weekly, evening and daily journals, and spent 32 years on *The Guardian* in London, as letters editor, arts editor, literary editor and finally science editor. He has won five annual awards from the Association of British Science Writers, including a lifetime achievement award. h e is an honorary fellow of the *British Association for the Advancement of Science*. h e has contributed to the *Lancet*, the *British Medical Journal*, *New Scientist*, *The Scientist* and the *London Review of Books*. h e is married with two children and one grandchild.

Christoph Rehmann-Sutter is Professor of t heory and e thics in the Biosciences at the University of Lübeck in Germany. First training in molecular biology at the Biocenter at the u niversity of Basel, then doing a second academic training in philosophy and sociology at the u niversities of Basel, Freiburg im Breisgau and the t echnical u niversity Darmstadt, he has specialised in bioethics. Since 1996, he has been h ead of the u nit for e thics in the Biosciences at the u niversity of Basel and holds a Visiting Professorship at the l ondon School of e conomics. From 1999–2002, he was president of the Swiss Society for Biomedical e thics and from 2001–2009 he has been Chair of the Swiss n ational a dvisory Commission on Biomedical e thics. h e has widely published and taught on biomedical ethics, research ethics, environmental ethics and philosophy of biology, especially genetics and end-of-life decisions.

Stephen Strauss has written about science for close to 30 years, initially at *The Globe and Mail* newspaper in t oronto, and more recently for a series of places including the *Canadian Broadcasting Corporation*'s website, *The Times Higher Education Supplement*, *Readers' Digest* and *New Scientist*. h e has written a number of books, including *The Sizesaurus* and *How Big Is Big*, as well as book chapters on a variety of topics. h e has won numerous of awards, most recently a 2007 prize from the u niversity of British Columbia for best science article in any medium in Canada in 2006.

Jon t urney is a freelance science writer and editor in Bristol u K. Past lives have included being features editor of *The Times Higher Education Supplement*, teaching at University College, Imperial College and Birkbeck College London, and commissioning popular science books for Penguin Press. He is a science journalism laureate of Purdue University and a senior visiting fellow in the Department of Science and Technology Studies at UCL. His books include *Frankenstein's Footsteps: Science, Genetics and Popular Culture* (Yale, 1998) and – with Jess Buxton – *The Rough Guide to Genes and Cloning* (2007). His next book is *The Rough Guide to the Future*, due in 2010. See www.jonturney.co.uk.

Elmien Wolvaardt (BSc) is a science communicator from South a frica with a background in print and broadcast journalism and a passion for making science accessible to a wider audience. She is currently the editor of the *Community Eye Health Journal* (www.cehjournal.org), which aims to inform and inspire health practitioners working on blindness in the developing world. As a freelance writer and editor she has worked with the Science Media Centre (www.sciencemediacentre.org) and the Science and Development Network (SciDev.Net) in l ondon.

Preface

t he idea for a book on the ethical and metaphorical aspects of communicating the biosciences emerged from a chance encounter between three people in June 2006 at the *Euroscience Open Forum* in Munich. Rick Borchelt (Communications Director, Genetics and Public Policy Center, Berman Bioethics Institute, USA) gave a paper entitled 'n arratives of humility', inspired in part by a 2003 paper by Sheila Jasanoff on technologies of humility (reprinted in this volume). He called for a new type of science communication that would highlight trial and error, explain the significance of failure and sketch out the episodic, incremental and non-linear progress of scientific endeavours. The focus would be on reporting scientific advances as a process and not just as products. In a paper on the politics and ethics of metaphor given at the same conference, Brigitte n erlich engaged in a critical analysis of media coverage of the Woo-Suk Hwang cloning scandal and the routine use of metaphors such as 'science is a race' and 'scientific advances are breakthroughs'. Her findings confirmed previous research carried out by Nik Brown who found that '[s]cientific institutions and science correspondents routinely evoke the breakthrough motif when seeking to attract the interest of wider audiences.' in doing so, he pointed out, they 'lend credence to a culture which they may subsequently criticise when claims are revoked or judged to be hype' (N. Brown, 2000).

Elmien Wolvaardt, a science writer, listened to the talks given by Rick and Brigitte and suggested that it would be worth reflecting on the types of discourse favoured in science communication, the metaphors used to report on science, and the ethical implications they might have. She and other science writer colleagues agreed that finding good metaphors for new research is something of a creative art. h owever, once metaphors become established or popularised, using them can very quickly become an unconscious habit. Brigitte and Elmien began to ask questions such as: Could research by metaphor analysts be useful to jobbing journalists – if not to help them find new metaphors, then at least to warn them of potential pitfalls? Could research by science communication experts help metaphor analysts obtain a better insight into the creation and choice of novel metaphors and the more or less routine use of old metaphors in the process of communicating science? What are the challenges faced by science communicators in this process? What are the ethical implications of metaphorical and other framing activities? t hese are the some of the questions explored in this book.

t he following chapters will review linguistic and practical challenges faced by communicators of science, while focusing on one central issue: the ethical status of metaphor and framing in science communication and science journalism, especially in the biosciences. Some of the practical and ethical science communication issues discussed here may not be familiar to metaphor analysts, just as some more theoretical issues related to metaphor research may not be familiar to science communicators. We hope, therefore, that this book will stimulate dialogue between these communities and facilitate further collaborative research and investigation.

Since 2006, and our encounter in m unich, numerous studies have been published on the h wang scandal which focus on both the interaction between science and the media and the ethical issues relating to the research and peer review process. h owever, the role of metaphor in this context has been somewhat neglected. As every metaphor opens a space for thinking and acting in particular ways, every metaphor also has ethical implications for science and society, which need to be explored in more detail.

Reference

Brown, N. 2000. Organising/Disorganising the Breakthrough Motif: Dolly the Cloned e we m eets a strid the h ybrid Pig, in *Contested Futures: A Sociology of Prospective Science and Technology*, edited by n . Brown, B. r appert and a . Webster. a ldershot: a shgate, 87–110.

Acknowledgements

This book is the result of a collaboration between three scholars interested in various ways in science communication and metaphor. Brendon l arson came to the institute for Science and Society in n ottingham as a Visiting Fellow in 2003 to work with Brigitte Nerlich on metaphors relating to invasive species, and they have been corresponding about metaphor related issues ever since. Richard Elliott joined the institute for Science and Society as a PhD student in 2007, having previously worked as a science communicator in various arenas, including the American a ssociation for the a dvancement of Science and the British a ssociation for the Advancement of Science. Sincere thanks go to Neil Jordan, our commissioning editor at Ashgate who was always there to provide quick and helpful advice on all matters editorial. We are also grateful to the institute for Science and Society which provided some financial assistance.

Most importantly though, we want to express our gratitude to Rick Borchelt for his inspiration and support throughout the writing of this book. Rick would have loved to contribute a chapter on humility in science communication, but unfortunately fate intervened and prevented him from writing it. We also wish to thank warmly the contributors to this volume for delivering their chapters in a timely manner.

Last, but not least, we would like to thank each other for mutual inspiration and smooth cooperation in the process of editing, something that cannot be taken for granted, as anybody knows who has ever edited a book!

Brigitte n erlich, r ichard e lliott and Brendon l arson

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Chapter 1

Communicating Biological Sciences: a n introduction

Brigitte n erlich, r ichard e lliott and Brendon l arson

Science communication, ethics and metaphors

This book deals with science communication, especially the communication of biological sciences. But it approaches science communication from two perspectives that have never before been used together to discuss the aims, process and effects of science communication, namely: ethics and metaphor. t here are, of course, many books and articles on science communication and ethics, and even more on journalism and ethics and the ethical dimensions of public communication of science and technology, some of which will be mentioned in due course. m any books and articles have also been devoted to science, science communication and metaphor; and again references to some of these will be made throughout. in this book we attempt to knit these efforts together and to shed some new light on the ethical *and* metaphorical dimensions of science communication.

By science communication we mean the reporting of technoscientific, especially biotechnological, knowledge and developments to non-scientists through popular science books and journals, newspapers and magazines, the broadcast media and 'public engagement' activities such as science fairs, museums and café scientifiques (see Stocklmayer et al. 2001). Some of these engagement activities have a long history (Gregory and Miller 1998), while others have emerged after older models of 'communicating science' had become problematised by theoretical developments in the social sciences but also by developments in science itself.

in the 1980s, a then new model of science communication, the so-called 'public understanding of science model' (Bodmer 1985; Miller 2001), had become the subject of growing critique. Social scientists increasingly challenged as ethically dubious its key underlying assumption: that giving laypeople more information about science will necessarily promote the acceptance of scientific and technological advances and lead to greater uptake of science subjects in school and as a career. t hey pointed out that this assumption is based on a 'conduit' metaphor of communication (Reddy 1979) on the one hand, and a 'deficit' model of knowledge and understanding on the other (for a good overview from the perspective of a science writer, see Dickson 2005). Messages, or 'facts' about science, are portrayed as being transmitted in a linear fashion from experts, those who know, to laypersons, those who have a deficit in knowledge. This model overlooks the fact that communication is grounded in dialogue, contextual understanding and the co-construction of meaning. While laypeople may perhaps know fewer 'facts' about science *per se*, they still have a good understanding of the social and political function of science in society. t hat is, they have what one might call good ethical antennae. in this context, trying to improve our understanding of science communication becomes an important task for both social scientists and scientists themselves. This book contributes to these continued efforts.

Developments in science itself, including shifts in the politics of science and science funding, have also served to complicate existing conceptions of science communication. a recent issue of *research eu: the magazine of the European research area* (2008) included a special report on science journalism entitled 'The science storytellers':

> Science is progressively acquiring a new role as the progress it makes is seen as vital for the future. t he media are also assuming growing importance with ever more codified means of communication. At the interface between the two, science journalism is undergoing a fundamental change that is affecting scientists as much as journalists, as their specific constraints often cause expectations to diverge. (d'Hoop 2008: 6)

Storytelling by science journalists is constrained by a variety of evolving issues, especially the diversification and acceleration of scientific research and the diversification and acceleration of science journalism. Two other developments in science and science communication herald increased tensions in the future. Demands are increasingly placed on science to generate innovative and commercial products with applications that benefit society and boost national markets. The second is the progressive and accelerating diversification of the media, aided by new outlets, new technologies (satellite television, the internet) and new genres (such as blogs, see Holliman et al. 2008); all this is accompanied by increasing demands for 'fast news' (see Gross 2008; Rosenberg and Feldman 2009). We do not directly address the increasing commercialisation of both science and science journalism here. Instead, we focus on an issue intimately connected with these developments and one of the major material and ethical challenges facing scientists and science communicators today: hype. As Bubela, Nisbet et al. (2009) have pointed out: 't he orientation towards hype is viewed internationally by many scientists, ethicists, policymakers, and government officials as the primary shortcoming of the media.' (p. 516)

Here, we briefly summarise some of the potential ethical difficulties related to the use of hype in science communication and explore some conceptual issues inherent in science communication itself, including framing, storytelling and the use of metaphor. We conclude by considering some major practical and ethical components of modern science writing.

Some (ethical) perils of science communication

r ecent scandals in the biosciences, especially the South Korean stem cell scandal, have highlighted some ethically problematic aspects of science publishing and science communication in an age of increasing competition for research funding, academic status and public recognition (Bogner and m enz 2006; Weingart 2006; Gottweis and Triendl 2006; Franzen et al. 2007; Chekar and Kitzinger 2007; Hong 2008; Kruvand and h wang 2008; Kim 2008; Kitzinger 2008; Jonyoung in press; Park et al. in press; Augoustinos et al. in press; and Nerlich, this volume). In particular, as we discuss in subsequent chapters, such scandals reveal fundamental weaknesses in the traditional use of framing and metaphor in science storytelling.

In 2004, the discoveries of Woo-Suk Hwang seemed to herald the dawn of regenerative medicine and a future in which the tissues and organs of every individual could be repaired and revitalised using their own genetically-matched stem cells. His work was published in a reputable science journal and greeted with enthusiasm by the media as a breakthrough achievement. But after Hwang's 'fall from grace' questions arose, not only about the scientific peer review system and the pressures placed on scientists to succeed, but about the nature of science writing and the media's seeming complicity in hyping up scientific breakthrough claims. Some analysts have called for greater humility in science writing (see Wolvaardt on Borchelt, this volume) and a greater awareness of the power of framing in general and metaphors in particular in science communication (n isbet, this volume). Some, such as the Science Media Centre in the UK, have begun to take practical steps to address such problems (Fox, this volume).

While it should be stressed that the h wang scandal does not stand alone (there have been other science/communication scandals in the past and there will surely be others in the future), it does appear to have had a particularly strong impact in bringing to light ongoing changes, in both science and the politics of science, which increase the likelihood of hype and fraud in these fields. These changes have been increasingly discussed not only by social scientists and media analysts but also by science communicators themselves (see Wolvaardt, this volume).

in 2007, delegates to the 5th World Conference of Science Journalists heard that science journalists need a new, or at least better, code of ethics if they are to communicate increasingly complicated science accurately. Bob Williamson, a professor of medical genetics at the u niversity of m elbourne and an active science communicator, told a conference session that such a code would help both scientists and science journalists define what constitutes legitimate science reporting. As reported by Jia (2007), Williamson implied that both scientists and science journalists are implicated in the hyping of research findings. Another delegate, r ob m orrison, vice-president of a ustralian Science Communicators, presented research showing that almost half of the 2006 news releases posted on the science press website EurekAlert were labelled as 'breakthroughs'. He pointed out that overuse of the term fuelled the hype surrounding science, but noted that such sensational language was all too often necessary to grab the attention of editors (Wormer 2008, see also Radford and Nerlich, both this volume). In his report on the conference, Jia goes on to point out:

> Wolfgang C. g oede, senior editor of g erman science magazine P.m ., highlighted the increasing influence of public relations in science communication, with institutions using science reporters to paint a positive image of their work. Goede said a code of ethics could include rules and descriptions to help journalists distinguish science news from public relations material. Pallab g hosh, a senior science reporter at the BBC and the incoming president of the World Federation of Science Journalists, said it was more important for science reporters to improve their general journalistic skills than have a code of ethics. 'It is easy to understand the research and peer review process, but what's needed more is the sense of finding the new and exploring the truth,' said Ghosh. He said the World Federation has no plans for a code of ethics, but will continue to help train science journalists in better practice. (Jia 2007)

Whether the World Federation of Science Journalists adopts a code of ethics or not, increasing attempts in other forums to put the ethics of science communication on a more academic footing, including the Science r esearch Communication e thics Project at Kansas State University in the United States[1] and the t hree-e model in the Netherlands (see Osseweijer 2006), testify to the fact that these issues are unlikely to go away. Other efforts, such as the development of a special section on the ethics of science journalism in the journal *Ethics in Science and Environmental Politics*,[2] demonstrate that the ethics of science communication is attracting increasing attention from academics and science writers alike (see Murcott, this volume).

Over and above the broadly defined ethical aspects of science communication, one of this book's central concerns is the ethics of metaphor use in science communication. a s John Dupré has pointed out, 'it has long been argued that all science depends on metaphors. Understanding grows by the projection of a framework through which we understand one kind of thing onto some less familiar realm of phenomena' (Dupré 2007).

Metaphors in science can have theory-constitutive (Boyd 1979), explanatory and communicative functions, and ethical complications can result from all of these. Some of these issues will be discussed in more detail in the following chapters. Jon t urney, for example, focuses on the explanatory function of metaphor while others, like Brendon Larson, Iina Hellsten and Brigitte Nerlich focus more on the communicative function.

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1 See www.k-state.edu/philos/ethics-science-communication/index.html.

2 See http://www.int-res.com/journals/esep/theme-sections/ethics-of-science-journalism. For more on academic attempts to engage with science journalism ethics, see Clarke 2008, B. Ward 2008 and S. Ward 2008 and 2009 (forthcoming).

t he focus of this introduction and many of the chapters (e.g. those by h ellsten, Larson, Nerlich, Balmer and Herreman) will be on the communicative function of metaphor and the ethical issues that surround it. But metaphor is also important in the process of science itself (see for example r adman, ed. 1995; t . S. Brown 2003; Baake 2003). We must stress that even the use of metaphors as constitutive *scientific* devices is not devoid of ethical issues. The field of genetics was partly built on metaphors that stemmed from historically salient discourses about information sciences, early computing and encryption (Kay 2000). While this may have helped to advance scientific discovery, it has clear implications for how we 'see' people, in a genetic context, as mere carriers of genetic information, and thus how we deal with health and disease. e arly cognitive science framed the brain as a computer which, again, has advanced our understanding of cognitive processes, but also has ethical implications. o ur ongoing 'war' against invasive species or infectious diseases carries with it a host of ethical, social, political and environmental implications (see Larson et al. 2005). As one scholar said, metaphorically, 'metaphor is the cognitive fire that ignites when the brain rubs two different thoughts together' (States 2001: 105). This can create an instant glow of cognitive contentment or ignite serious arguments. The use of both fire and metaphor has ethical implications. Both are 'technologies' that can change the world as we know it. They can give pleasure or pain and be used for good or for evil, but human civilisation cannot do without them. in science communication they are essential, as has recently been pointed out by the protagonist of the novel *The End of Mr Y* (Thomas, 2008: 29): 'I quite like the way you can talk about science without necessarily using mathematics, but using metaphors instead. t hat's how i've been approaching all my [magazine] columns. For each of these ideas and theories, you find there's a little story that goes with it.'

Language, whether of the breakthrough-and-hype or humility-and-honesty variety, is the essential tool scientists and journalists use when they engage in scientific discovery and scientific storytelling. Metaphors can be used to highlight and hide or foreground and background issues for specific purposes. It can attract attention, increase funding, excite people, encourage them to accept a new technology and so on. Clearly, this process has political and ethical implications that need to be understood and discussed. An understanding of how journalists (in their interaction with science and scientists) construct their stories for various audiences is therefore likely to be beneficial to journalists themselves as well as scientists, policymakers, linguists and the wider public alike.

in the context of decreasing trust in some aspects of science and technology and increasing calls for public engagement (Starling 2002; Wynne et al. 2005), the activities of 'mediators' between science and various publics have become both more important and more perilous than ever. in light of the h wang scandal, and following increasing accusations of 'technoboosterism' in scientific discourse (Michelle 2006), some analysts have begun to echo Sheila Jasanoff in calling for 'discourses of humility' as a replacement for the 'discourses of hype' that dominate science and science communication. But the process is far from straightforward.

e xpert commentators are already struggling to report on complex and rapidly-developing issues in science and society while working within conceptual and temporal constraints that inevitably shape the way science is mediated and communicated. t o successfully navigate a path between hype, hubris and humility we must incorporate these elements into our reflections on the ethics of science communication. t he following discussion therefore provides an overview of some of the main conceptual, practical and ethical issues that impinge on science communication, especially in the fast-moving fields of the biosciences.

f rames, metaphors and stories

In a lecture for the Centre for the Study of Democracy, Sheila Jasanoff (2007) noted that 'to maintain trust between experts and publics requires us to think of democracy as a performance whose scripts call for constant and critical reflection and oversight'. a critical analysis of 'scripts' in science and policy and their 'performance' in the media is an essential component of such reflection. In this book we analyse such scripts through three main methods: frame analysis, metaphor analysis and discourse analysis.

What Jasanoff calls scripts, others call 'frames'. Tankard et al. describe a media frame as 'the central organising idea for news content that supplies a context and suggests what the issue is through the use of selection, emphasis, exclusion and elaboration' (1991: 5). Part of this book, especially the contribution by Nisbet, will be devoted to a critical reflection on framing in science communication. We use some aspects of frame analysis to explore the ways in which media organise and contextualise scientific ideas, advances and change. Another important tool for those wishing to reflect on the role of science communication in a wider political context is the field of discourse analysis. Discourse analysis is linked to frame analysis insofar as it provides a means for studying the structure and meaning of texts in the context of the social, political and cultural situations in which they are produced.

Our final tool, metaphor analysis, is linked to both of these. Metaphors can be used to frame scientific issues, construct new meanings, shape ideologies, and structure discourses, narratives and stories. In particular, the new field of critical metaphor analysis links up directly with a subfield of discourse analysis, namely critical discourse analysis (see Charteris-Black 2004; Musolff 2004). These three methodologies – frame analysis, metaphor analysis and the analysis of discourse – provide the basis for much of what follows in this volume. it is therefore useful to provide a short overview of these conceptual tools and their role in examining storytelling in science and the media (see also Haran et al. 2007).

a s will be made eminently clear in m atthew n isbet's chapter, framing is an unavoidable reality of the science communication process. Frames are interpretative packages and storylines that help communicate why an issue might be a problem, who or what might be responsible, and what should be done. Frames are used by lay publics as ‘interpretative schemas’ to make sense of and facilitate discussion of an issue; by journalists to condense complex events into interesting and appealing news reports; by policy-makers to define policy options and reach decisions; and by scientists to communicate the relevance of their findings. In each of these contexts, frames simplify complex issues by lending greater weight to certain considerations and arguments over others.

Frames can be triggered by the use of certain framing devices. t hese include comparisons to historical exemplars such as the h olocaust, n azi eugenics or past pandemics and plagues; stock literary characters, such as *Frankenstein* (on which so-called ‘Frankenwords’, such as *Frankenfood*, *Frankenfish*, *Frankencrops* are based); stock literary titles, such as *Brave New World*; stock religious or mythical allusions, such as the apocalypse, Pandora’s Box, icarus’s fall, Prometheus’ stealing of fire, and so on; and also and perhaps most importantly, metaphors.

Some scholars, such as Iyengar (1987), argue that frames for a given story are seldom consciously chosen but represent instead the more or less unconscious effort of the journalist to convey a story in a direct and meaningful way. As such, news frames are frequently drawn from, and reflective of, shared cultural narratives and myths and resonate with the larger social themes to which journalists tend to be acutely sensitive. h owever, others, such as e ntman, hold that ‘[t]o frame is to select some aspects of a perceived reality and make them more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation, and/or treatment recommendation.’ (e ntman 1993: 52) For him, this selection or choice of frame is an active and conscious process. h ere, we assume that both conscious and unconscious processes are at work in the selection and use of metaphors and frames.

a chosen frame suggests what is relevant about an issue and what should be ignored. u sing a variety of framing devices, the ‘human genome’, for example, has been positively framed as a gold mine, a key to unravelling life’s mysteries, a wondrous map, and so on. Frames emphasise certain attributions of the causes and consequences of an issue and they also tell us who or what is responsible (see Gitlin 1980). They also have direct financial and economic, and therefore ethical, implications regarding, for example, the exploitation of genomics for the creation of wealth or the alleviation of disease.

Frames do not seem to change greatly over time and across cultures. in this they are quite similar to standard metaphors used as framing devices (see Nerlich and Hellsten 2004; Turney 2005; and Hellsten, this volume). This means that the ethical connotations and implications these framing devices carry with them as historical ballast also stay relatively constant and unchallenged. e ntrenched framings are not easy to shift and can blind our imagination to other possible ways of grasping developments in science and technology. This is quite astonishing, as one would assume that ‘[t]he imagination offers a playful space to test “what-if” scenarios – sites for reconfiguration – yet scientists and journalist all too often revert to familiar images if they want to sketch potential implications of the new genetics’ (van Dijck 1999: 20).

Frames have ethical implications not only because of their relative stability over time, but because they can also be used across science by a variety of stakeholders who have quite different purposes but still use similar frames. On one hand this can create mutual understanding, on the other it can lead to misunderstanding.

Frames do not exist in isolation. They evoke and are linked to shared storylines and storytelling. ‘The point of the story-line approach is that by uttering a specific element one effectively reinvokes the story-line as a whole. It thus essentially works as a metaphor.’ (Hajer 1995: 56) Storylines employ symbolic references that imply a common understanding of an issue (Hajer 1995; Rydin 1999). Essentially, the assumption is that actors do not create a whole new comprehensive discursive system every time they write or talk about a new issue in the biosciences: instead an already existing one is evoked through references to story-lines. By uttering a specific word or phrase, for example ‘global warming’, a whole storyline is in effect re-invoked; one that is subtly different from that of ‘the anthropogenic greenhouse effect’ or ‘climate change’. ‘g lobal warming’ implies a storyline wherein the whole earth gets hotter in the future; ‘climate change’ suggests something less certain and uniform; and ‘anthropogenic greenhouse effect’, perhaps the most technically correct term, directly attributes the warming effect to human activity (see Whitmarsh, in press). Dismantling dominant storylines is just as difficult as dismantling dominant metaphors (see Nerlich and Hellsten 2004).

Metaphors, storylines, narratives and frames are intimately linked. While metaphors may help us capture novel events in terms of the familiar, ‘[t]here is a concomitant risk, of course: the metaphorical constructs also limit our ability to assimilate new information and, in conventional discourse, where certain literalness prevails, they can quickly lose their suppleness and become mere props for unreflective traditionalism’ (Leiss 1985: 148–9). This, again, can have ethical consequences.

u ntil now, we have used the term ‘metaphor’ in a relatively loose sense. However, there has been a boom in metaphor research since the 1980s, when Lakoff and Johnson (1980) introduced the concept of the ‘conceptual metaphor’ and launched the new field of ‘cognitive linguistics’. In the cognitive view, metaphors help us to understand an abstract or inherently unstructured subject in terms of a more concrete, highly structured one. m etaphors are not merely linguistic but cognitive phenomena, and they are necessary for our thinking, acting and speaking (Ortony 1975). Metaphors are conceptual devices, rather than rhetorical ones, but they are also, we suggest, social devices which have important political and ethical implications. a s the eighteenth-century philosopher and wit g eorg C. l ichtenberg remarked ‘we do not think good metaphors are anything very important, but I think that a good metaphor is something even the police should keep an eye on’ (Lichtenberg 1990: Aphorism 91). While, for the literary critic I. A. Richards, a command of metaphor plays a crucial role in ‘the control of the world that we make for ourselves to live in’ (1936: 135–6). That is, by using metaphors we wield power, not only over how we make others think but also how we make others act in the world.

So-called conceptual metaphors, such as ARGUMENTS ARE WAR (and their linguistic realisations, e.g. 'She spearheaded the debate'; 'he shot down her argument') are seen as mappings across at least two conceptual domains: the conceptual source domain (e.g. war) and the conceptual target domain (e.g. arguments). These mappings are not arbitrary. r ather, they are grounded in our everyday experience of the body and the world we live in. it is assumed that conceptual metaphors are, for the most part, unconsciously and automatically accessed and processed (for a nice demonstration of this phenomenon read Radford, this volume). We only become conscious of this process when highly poetic and novel metaphors are created (see Strauss, this volume). This corresponds to what the policy analysts Schön and r ein say about frames – and what they say about policy positions can also be said to apply to positions taken by scientists, social scientists and science journalists:

> We see policy positions as resting on underlying structures of belief, perception, and appreciation, which we call 'frames.' [...] m oreover, the frames that shape policy positions and underlie controversy are usually tacit, which means that they are exempt from conscious attention and reasoning. (Schön and Rein 1994: 23)

Metaphor analysts need, in fact, to reflect more deeply on the ethical implications of metaphor use and whether the unreflective use of conceptual metaphors has different implications when compared to the more deliberate, reflexive and indeed political use of metaphors.

The function of metaphors, stories and narratives is therefore not just a descriptive one; they do not merely represent facts or fictions. They have a performative, and therefore political and ethical, force. a s Bono has pointed out, metaphors are 'invitations to action' and narratives are 'user manuals' for putting metaphors into action and learning to work with and through metaphors (Bono 1990). 'The work of metaphor', Bono argues, 'is not so much to represent features of the world, as to invite us to act upon the world as if it were configured in a specific way like that of some already known entity or process' (Bono 2001: 227).

m etaphors can be used by experts and the media to shape visions of the past and/or the future in order to try and affect our social and political actions in the present. t hey can also be used to orientate users (whether as institutions, groups or individuals) to particular possibilities for action and have an effect on material investment (Brown and Michael 2003). This might include using positive expectations to, for example, get funding for scientific research or persuade participants to donate oocytes, or negative expectations to persuade funding agencies to increase support for new lines of inquiry, persuade governments to stockpile the antiviral drug Tamiflu or change antibiotic prescription behaviour and so on (see Nerlich and Halliday 2007; Nerlich 2008 and this volume).

t he ethical implications of frames and metaphors emerge from the fact that metaphors and images create visions and expectations that set patterns for action.

Actions can be financial investment and support, but also emotional investment and support (such as h wang received from many female supporters in South Korea, see Herold 2007). Discourses and metaphors shape patterns of public acceptance, rejection, trust or scepticism. These are of particular importance in the biosciences, where such patterns of thought and action are likely to have a direct influence on, for example, our attitudes to novel health technologies or our concerns about the loss of biodiversity.

Overall then, frames and metaphors are major sense-making instruments in the process of science and integral tools for storytelling in science, science communication and the public domain. t hey are what m aasen and Weingart call 'messengers of meaning' (Maasen and Weingart 1995, 2000). In their more cognitive function, they facilitate cross-domain communications (Bono 1990) and knowledge creation and transfer. In their more pragmatic function, they also orient users (whether as institutions, groups or individuals) to particular possibilities for action regarding science and technology (Van Lente 2001). Metaphors shape expectations, structure the involvement of actors and orient users' involvement with science and technology. Some of these issues have been studied in the sociology of expectations, but more research is needed into the ethics of expectation management in science communication that uses metaphors or other visual and/or verbal framing devices.

l et us now turn to some of the practical and ethical issues that science communicators face in the modern world when using frames and metaphors to tell and/or sell their stories.

Science storytelling in the real world: Problems, challenges and opportunities

in a recent commentary on science communication and public engagement, Bubela, Nesbit et al. (2009) have drawn attention to the fact that surprisingly, and contrary to what one might expect, much of the science coverage in the media is quite accurate and that, on the whole, scientists are quite satisfied with the coverage they receive (see h oltzman et al. 2005; Peters 2008; see also see also Bubela and Caulfield 2004, Bubela 2006). Despite this, there remains a deep-seated prejudice that science communication distorts science, spins science and hypes science, as testified to by a recent lecture by the science commentator Ben Goldacre, entitled 'h ow the media promote the public misunderstanding of science' (see also Goldacre 2008).

in this context, many academic articles, editorials and reports have been published that recommend best 'practices and checklists for journalists' (Bubela, n isbet et al. 2009: 516; Blum et al. 2005, Schwitzer 2005, Woloshinov and Schwartz 2006 and many more). Such books and articles may be read by professional science writers and communicators, but whether such recommendations or ethical maxims trickle down to the new breed of science bloggers and twitterers is a matter for future research. it is also not clear whether such standards, norms and ethical frameworks impinge on those writing press releases, a genre of science writing that mediates more and more between science and science communicators.

Science blogs are becoming increasingly important as mediators between science and various publics. Unlike traditional news articles, they create a dialogue with readers, merging online interaction with real world socialising at science cafés and other informal settings. Science bloggers frequently vet false claims made in the media or in policy debates and increasingly serve as important sources for journalists (see Bubela, Nisbet et al. 2009). Through the advent of wiki sites and developments towards Web 2.0, 'knowledge' becomes ever more democratised (see Giles, 2005) and the distinction between laypeople and experts, as well as accredited science writers and other science communicators, becomes eroded. Some even claim that the difference between science writer and reader is beginning to shift in this context (see Strauss 2009). And finally the distinction between what is hidden and what is disclosed is blurred. 'instead of an interpretation of what someone meant, a writer can include a link that says effectively: "Here is the background material I used. Here is me interviewing the subject on a podcast or a video and here is precisely what he/she said. h ere is the raw material out of which i constructed my dialectic, and you can decide whether i got the argument right or wrong based not on the power of my rhetoric but on the facts at hand."' (Strauss 2009) The ethical implications of these shifts are far reaching. One of the more obvious ones is that codes of ethics (based on the norms or maxims of accuracy, balance, objectivity and impartiality) that apply to professional communicators and which are ingrained in their science communication practice (see murcott, this volume) may not reach other non-professional ones.

Another issue highlighted by Bubela, Nisbet et al. (2009) is that 'scientific papers are relentlessly quantitative, while media articles are based on humanised accounts that connect with lay readers' (p. 516), often through metaphors that resonate with popular images and narratives. Scientific articles are aimed at a narrow, specialist audience while media articles are aimed at a broader audience. As a result, journalistic accounts tend to be based more on personal anecdotes provided by either scientists or those most likely to be impacted by the research. Without this connection, a science story in competition with the other news of the day may not get published (see Bubela, Nisbet et al. 2009.).

Finally, the greatest challenge that science communication will face in the future is the problem of fragmentation on the one hand and choice on the other. in a world were the means of communicating science as well as the genres and styles are multiplying, how do science writers actually reach their audiences and how do audiences choose what to read, listen to or view in what form, when and where, as individuals or collectives (through means such as Digg.com for example)? As Bubela, Nisbet et al. (2009) have pointed out: 'The availability of science information from credible sources online does not mean the public will use it. Even more so than in the traditional media world, if the public lack the preference for science content on the Web, they can very easily ignore it. t his has implications for greater engagement of the public with science policy debates.' (p.514) And whom do journalists themselves choose as their 'credible sources'?

What is the solution, if any? a s Bree n ordenson recently pointed out in an article, 'o verloaded', published in the *Columbia Journalism Review*:

> The greatest hope for a healthy news media rests as much on their ability to filter and interpret information as it does on their ability to gather and disseminate it. If they make snippets and sound bites the priority, they will fail. Attention – our most precious resource – is in increasingly short supply. t o win the war for our attention, news organisations must make themselves indispensable by producing journalism that helps make sense of the flood of information that inundates us all. (Nordenson 2008)

Framing and metaphor are some of the most important sense-making devices. We therefore need to understand how they work and how we can use them 'ethically'. t hus far, the ethical aspects of metaphor use have not been discussed, it seems, in handbooks of journalism or journalistic codes of ethics. Some journalists have reflected on metaphor, but not systematically. For example, in an article on 'news writing', Peter Cole of *The Guardian* considered only extended metaphors:

> Headline writers love puns and phrases from 60s pop lyrics and editors frequently have to restrain their use. t hey sit even less easily in copy, where only readers over 55 can identify them. a gain, the danger is excluding readers. Worst of all is the extended metaphor or pun. Like this (real) one: 'Kingsbridge Silver Band has hit a high note with n ational l ottery chiefs to the tune of nearly £52,000. Tired old instruments struck a chord with the lottery board, which has drummed up enough cash for a complete new set, giving the band plenty to trumpet about.' Yes, really. (Cole 2008)

Such 'situated metaphors' abound in news reporting, where it is almost impossible to write or broadcast a report on, say, an issue relating to cars or bicycles without starting it by saying: 'Wheels are set in motion to ...' (accompanied, if possible by a picture of spinning wheels!).

However, the above quote points to the important issue of the interaction between science communicators and editors in the process of science communication, which puts certain, very practical, constraints on the work that science communicators do. a nother issue is that there is often no real time to engage in such word play. in the process of science writing metaphors are useful, especially those that illuminate certain aspects of science. But finding new ones takes time and it is sometimes easier to grab a metaphor that is already widely in circulation. n ovel metaphors may not survive the editorial process if science story editors insist on metaphorical 'hooks' that are easily understandable and resonate with as wide an audience as possible. it thus becomes easier to perpetuate older, more clichéd metaphors, rather than to invent novel and thought-provoking ones (see Strauss, this volume).

Even more than metaphors, making sense of science relies on the general 'social' interaction between science and the media and scientists and science communicators. in facilitating communication between science and the media, the UK benefits from a new intermediary, namely the Science Media Centre (SMC), which has become, in a sense, a 'messenger of meaning' between science, the media and various publics (see Fox, this volume). By mediating the space between science and the media, the SmC has the potential to alleviate or correct many problems that have bedevilled the relationship between science, the media and its publics in the past. it may also counteract some of the new problems and challenges thrown up by the ever-expanding and accelerating real and virtual media worlds. in some cases, it could even turn what we have listed above as problems and challenges into opportunities.

o verview of chapters

The book has four parts. Part I sets the scene with two articles which helped to inspire the writing of this book. Written by a journalist and a science and technology studies specialist respectively, these articles address the issues of hype and humility from a journalistic and a scholarly perspective. Part II deals with issues of science communication from the perspective of theory and practice, with a special focus on the ethics of science communication. Part iii contains vivid accounts by practising science writers of dealing with issues of hype, humility and metaphor on a day-to-day basis. Finally, in Part iV, we present a number of analytic pieces by specialists in metaphor analysis who examine the use of metaphors in the interaction between scientists, journalists and public as they respond to various events in the biological sciences.

Part I of the book begins with Chapter 2, by Elmien Wolvaardt. This is a reprint of a short article she published shortly after the meeting in munich at which we hatched the plan for this book (see Preface), and in which she critically reviewed two talks, one by Rick Borchelt on science communication and humility, which was itself inspired by Sheila Jasanoff's paper (which has become Chapter 3 of this book), and one by Brigitte Nerlich (which has become Chapter 13). Chapter 3, by Sheila Jasanoff, is a reprint of a paper, originally published in a 2003 edition of the journal *Minerva*, on 'technologies of humility' (see also Jasanoff 2007). She argues that science and technology policy is conventionally governed by 'technologies of hubris,' which tend to emphasise secrecy, expertise and the privileging of institutional agendas. But this approach has not, by and large, been beneficial for either science or society. Instead, Jasanoff suggests, policy-makers need a set of 'technologies of humility' which systematically assess the unknown and the uncertain in accordance with a more broadly normative context. a t the Munich conference Rick Borchelt argued that science communicators need a similar norm of humility. o ne science blogger, a ndrew m aynard, responding to Borchelt's subsequent discussions of technologies of humility in the context of nanotechnology, remarked:

> Jasanoff's arguments and use of language will be unfamiliar to many involved in the generation and use of scientific knowledge – her use of the word 'technologies' for instance refers to the social and policy-based mechanisms of how science is done. Yet her conclusions are clear – in today's evolving society, we cannot continue to force new sciences and technologies into old ways of thinking. The simplistic separation of research into basic and applied studies has dominated science policy for over half a century. Yet according to Jasanoff, this model no longer works. Instead, we need new approaches that acknowledge the partiality of modern science; that recognise the context within which research is conducted; and that respond to new ways of generating scientific knowledge. (Maynard, 2007)

What is needed, Jasanoff argues, are 'methods, or better yet institutionalised habits of thought, that try to come to grips with the ragged fringes of human understanding – the unknown, the uncertain, the ambiguous, and the uncontrollable' (Jasanoff, this volume). Whether entrenched patterns of practice and language allow such a new way of thinking is a matter for analysis and reflection – some of which takes place in this book.

Part II of the book begins with Chapter 4, written by media and frame analyst m atthew n isbet. n isbet deals with the ethics of framing from the point of view of a science communication analyst. h e stresses that there no such thing as unframed information, and most successful communicators are adept at framing, whether using frames intentionally or intuitively. indeed, whether it is a scientist giving Congressional testimony, a public information officer writing a press release, a journalist crafting a news report, or a lay citizen speaking out at a public forum, framing is an unavoidable reality of the communication process. t herefore, the choice is not whether to employ framing, but rather across these contexts, how to effectively and ethically frame a message for an intended audience. Some of this framing activity depends on the role played by scientists and journalists, as issue advocates or honest brokers – and in both roles the ethical imperative of accuracy and truth-telling applies.

Chapter 5 by the philosopher and bioethicist Christoph r ehmann-Sutter sheds more philosophical light on what it means to do science in the public sphere, a public sphere that is also always a cultural sphere. He argues that reflecting on the social construction of the ethical, legal and social aspects of scientific research could help to improve the ethical responsibility of science communication, both with regard to normative decision-making, and with regard to understanding and explaining science. Chapter 6, by science writer t oby m urcott, introduces the issue of the ethics of science communication from the perspective of a practising journalist. Murcott addresses the challenges faced by journalists who report science news and argues that opening science up to greater scrutiny would allow journalists to discuss the process of scientific research as well the results. One pitfall science communicators should avoid if at all possible, he explains, is to frame science as a deity and science journalists as priests and to become an advocate for science (see also Larson, this volume). Whereas Murcott grapples with the ethical problems of mediating between science and the readers of popular scientific articles, Fiona Fox deals with another issue of 'mediation' in Chapter 7, namely that of negotiating a better relationship between scientists and journalists, and, in the process, improving science communication. She discusses the contribution that l ondon's *Science Media Centre* makes by encouraging scientists and journalists to engage with each other when controversial scientific stories hit the headlines.

Part III of the book begins with Chapter 8, in which the science writer and science communication expert Jon t urney grapples with the changing metaphors of genes and genomes. He looks at how these popular conceptual tools are becoming increasingly ineffectual as scientific accounts of DNA, RNA and protein molecules continue to develop. Chapter 9, by t im r adford who was, until 2005, science editor of *The Guardian* provides a vivid insight into the daily work of a science communicator who is at one and the same time highly sensitive to metaphor and hyperbole but also falls prey to their alluring beauty. in Chapter 10 the science writer and broadcaster Stephen Strauss tells us how he coaxed a wonderful metaphor out of his audience, but also how he debated the pros and cons of another less beautiful but even more effective one with its creator.

The last part of the book opens with Chapter 11 in which Brendon Larson deals with the same metaphor, 'Dna barcoding', as well as another, 'invasional meltdown.' He subjects both to a critical analysis in terms of whether scientists should or should not advocate by using what Dorothy Nelkin called 'promotional metaphors.' in Chapter 12, the media and metaphor expert, iina h ellsten explores the implications of the temporal discrepancies in popular metaphors of science and technology for the ethics of science communication. Science's 'journey', for example, does not refer to cross-Atlantic flights; instead, it often suggests images of science conquering new territories or new frontiers. Similarly, it would not make sense to metaphorise the genome as a text, indeed as the 'book of life', if 'text' meant a set of ephemeral postings on the internet. r ather, 'texts' carry connotations of civilisation, of g uthenberg and the library of a lexandria. t he implications of these temporal discrepancies are normally overlooked in science communication, but should be scrutinised, especially for their ethical implications. t his is followed by Chapter 13 in which another metaphor and media expert, Brigitte n erlich, examines a different directionality of metaphors, namely the ethical use of future-oriented metaphors of breakthrough and disaster in science communication, specifically in the context of the Hwang scandal and in the context of the MRSA controversy in Britain. The final chapter is devoted to the so far final (but probably soon to be superseded) chapter in the evolution of the 'new genetics'. in Chapter 14 a ndrew Balmer and Camille h erreman engage in an analysis of the u K media coverage of Craig Venter's promotion of the new science of 'synthetic biology' across the u K and they study in particular how metaphors used by him and other scientists as well as by the media perform ethical functions.

We hope that this book will open the eyes of those engaged in metaphor analysis to the daily lives of those who use and re-use metaphors every day. We also hope that it will open the eyes of practitioners to the ethical issues of using metaphors every day and, perhaps, to the insights that metaphor analysis may bring to their trade. o verall, we want to stimulate discussion of the ethical and metaphorical dimensions of science communication amongst all 'stakeholders'. Science journalists have already discovered the power and relevance of 'storytelling', as the following quote indicates. Metaphors are some of the most important tools in good storytelling and awareness of their power should also be raised and become perhaps part of journalistic curricula. In a piece on 'Narrative science journalism', Wolfgang Goede reported on some events at a meeting of science journalists in 2004. What they said about storytelling also holds for metaphor – they very much go together, as metaphors encapsulate stories and as stories need metaphors to work:

> a s one participant put it, 'telling stories is probably the oldest form of communication which originated at the stone age camp fires'. There is a long tradition of storytelling which the bible gives impressive examples of; many famous fairy tales in the e ast and West demonstrate highly developed storytelling abilities. While many of today's grandmothers are wonderful storytellers, younger science writers were never trained in this. t he panelists, among them Peter Wrobel from 'n ature', agreed that this should be included into the curricula of European science journalists' schools and receive high priority. (Goede, 2005, online, some typos corrected by us)

Or as Mulkay wrote a decade or so ago, referring to biological sciences and their orientation towards the future:

> […] when people speculate about the development of new, science-based technologies, they cannot rely entirely on what they take to be the established facts. In thinking and arguing about the shape of things to come, they have no alternative but to create some kind of story that goes beyond these facts. (Mulkay 1997: 117)

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Part i

Setting the Scene: issues of hype, hubris and humility in Science Communication and Citizen Participation

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Chapter 2
h ow Journalism Can h ide the t ruth about Science

e lmien Wolvaardt

The problem-solving ‘breakthrough’ science of the media is far from the messy truth. So said Rick Borchelt of the Genetics and Public Policy Center of Johns Hopkins University, United States, to a gathering of scientists and science journalists at the second e uroscience o pen Forum in m unich, g ermany, in July 2006. t he media’s portrayal of science as objective and self-policing is, said Borchelt, ‘a narrative of hubris: it perpetuates the view that science is a linear process of steps and breakthroughs, and gives no account of the trials and errors that actually occur along the way.’ Borchelt, a former press officer in the United States’ Clinton administration, expressed concern that this image creates unrealistic expectations that science always gets it right. ‘When the inevitable errors then occur, confidence in scientific enterprise is eroded, eventually cultivating a cynical public,’ he said.

In the narrative of hubris (characterised by arrogance and a lack of insight), the focus is mainly on the products of science: its findings, outcomes and the implications for humanity, said Borchelt. ‘This means “breakthroughs” appear seemingly out of nowhere.’ But there is another way to present science, he explained: in a narrative of humility (see Jasanoff, this volume). ‘We must emphasise the fact that science is an incremental process, with many wrong turns and blind alleys – which is why it is important to report negative results.’

Digging deeper

Such journalism, said Borchelt, focuses on the processes, methods and people of science – a crucial element of science reporting. t his way of reporting is especially important in areas of highly uncertain, contested knowledge – think stem cell research and genetically modified foods. ‘The stakes are high. Would the fake South Korean cloning research have gone as far as it did, had science writers been taking a more critical and involved look at the processes and personalities involved?’ Borchelt asked.

But are Borchelt’s suggestions realistic? a nd why is there so little actual reporting on the process of science? Senegalese science writer a rmand Faye says it’s because the subject matter of science is so complex. ‘Most of my time is spent on making science understandable and exciting for my audience. I think this is a big distraction from reporting on the process of science.'

For South African broadcaster, journalist and author Christina Scott, airtime and column inches are her main constraint. 'in broadcasting and in print, the amount of time or space given is so restricted that I often feel like a Red Cross worker on the battlefield, practising triage,' she says. 'I save what I can, and abandon the rest. a nd yes, one of the facets of science which often gets abandoned is the rather haphazard nature of research and discovery.'

David Dickson, founder of SciDev.Net (Science and Development Network: http://www.scidev.net/en/) and former news editor of *Nature* has a different explanation. 'The processes of science are actually quite boring. Of course, if there is an interesting product or result at the end of the day, the processes by which this was reached can be interesting to read. But I don't think most people want to read about the average day of the working scientist.' He adds, 'However, it is very important for science journalists to understand the processes of science. This understanding should inform the way we report its products and results – which can include negative results.'

Wolfgang g oede, editor of the successful g erman popular science magazine PM (http://www.pm-magazin.de/de/openscience) and co-founder of the World Federation of Science Journalists, says journalists don't report on the process of science because 'very few of us have been trained and, more importantly, encouraged to look at science as if it were a political party or a public enterprise – those things we have been brought up to criticise.'

Mixed metaphors

In a talk at the Euroscience meeting, linguist and metaphor analyst Brigitte Nerlich of Nottingham University argued for more critical awareness of the 'breakthrough' metaphors so often used by those reporting on science (see Nerlich, this volume), which contribute to the persistent hubristic tone. 'In a way they just trip off the tongue, fall off the pen or emerge from the keyboard without the users of these metaphors being aware that they are using them,' she said.

Scott describes the media's focus on breakthroughs as 'both a blessing and a curse'. a lthough it highlights scientists' achievements, she says, it also hides the complex process of turning a discovery into a tangible product. 't hey hear the story, and want to order the product over the internet, not understanding that there may be clinical trials still to come.'

American science journalist Jim Cornell feels that Nerlich is only partly correct. Whereas science journalists are increasingly aware of the implications of using 'breakthrough' metaphors, non-science specialists may not be. Non-specialists include 'gate-keeper editors, who insist that reporters have "story hooks" that are quick and easy for the public to grasp'. These editors rely on metaphors, he says, because like clichés, they ‘make it possible to simplify and shorten complex concepts that can fit the abrupt and abbreviated style of the media.’

But the fault may not lie solely with the journalists or their editors, says Holger Wormer, professor of science journalism at Dortmund University in Germany. ‘It is often the scientists who invent and use metaphors that are too strong.’ a nd he estimates that ‘only one in fifty reported scientific breakthroughs is a real breakthrough, if ever’.

Clearer communication

n erlich applauded the efforts of science communicators such as Borchelt, who raise their own and others’ awareness of the tacit metaphors they are tempted to use. She advises writers to try using caveats with dramatic metaphors, or to simply use alternative metaphors.

Scott, too, offers practical advice. ‘It would be useful to journalists if a press release included phrases such as “warns that” to counteract overly ambitious coverage, “pays tribute to” to include other members of the team, “this is important because” to provide a glimmering of context, and “the next step is” to suggest that science is a process.’ Scott also feels that the focus on breakthroughs indicates very strongly that scientists are not participating fully in the process of disseminating information. ‘t hey are often unwilling to communicate at a level which is understood by the majority of citizens in the same society,’ she says. Borchelt agrees: in the u nited States, at least, he said, the pressure to generate research funding in an increasingly competitive grant environment means scientists have even less time to devote to helping the public or policymakers understand science. But such obstacles to communication don’t remove the burden of responsibility from scientists, he argues. Journalists, suggested Borchelt, are unlikely to change the way they report unless scientists themselves put a greater priority on engaging with the wider world.

a cknowledgement

t his article was originally published on 5 January 2007 on the website of the *Science Development Network* and has been reprinted here with permission by *SciDevNet* and with permission of the author.

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Chapter 3

t echnologies of h umility: Citizen Participation in g overning Science

Sheila Jasanoff

t he perils of prediction

Long before the terrorist atrocities of 11 September 2001 in New York, Washington, DC, and Pennsylvania, the anthrax attacks through the US mail, and the US-led wars in Afghanistan and Iraq, signs were mounting that America's ability to create and operate vast technological systems had outrun her capacity for prediction and control. In a prescient book, published in 1984, the sociologist Charles Perrow forecast a series of 'normal accidents', which were strung like dark beads through the latter years of the twentieth century and beyond – most notably, the 1984 chemical plant disaster in Bhopal, india; the 1986 loss of the *Challenger* shuttle and, in the same year, the nuclear plant accident in Chernobyl, u SSr ; the contamination of blood supplies with the ai DS virus; the prolonged crisis over BSE ('mad cow disease'); the loss of the manned US space shuttle Columbia in 2003; and the u S space programme's embarrassing, although not life-threatening, mishaps with the *Hubble* telescope's blurry lens, and several lost and extremely expensive Mars explorers (Perrow 1984). To these, we may add the discovery of the ozone hole, climate change, and other environmental disasters as further signs of disrepair. o ccurring at different times and in vastly-different political environments, these events nonetheless have served collective notice that human pretensions of control over technological systems need serious re-examination.

While American theorists have often chalked up the failings of technology to avoidable error, especially on the part of large organizations (Perrow 1984; see also Vaughan 1996, Short and Clarke 1992 and Clarke 1989), some European analysts have suggested a more troubling scenario. Passionately set forth by the German sociologist Ulrich Beck, the thesis of 'reflexive modernization' argues that risks are endemic in the way that contemporary societies conduct their technologically-intensive business (Beck 1992). Scientific and technical advances bring unquestioned benefits, but they also generate new uncertainties and failures, with the result that doubt continually undermines knowledge, and unforeseen consequences confound faith in progress. Moreover, the risks of modernity often cut across social lines and operate as a great equalizer of classes. Wealth may increase longevity and improve the quality of life, but it offers no assured protection against the ambient harms of technological societies. t his observation was tragically borne out when the collapse of the World t rade Center on 11 September 2001 ended the lives of some 3,000 persons, discriminating not at all among corporate executives, stock market analysts, computer programmers, secretaries, firefighters, policemen, janitors, restaurant workers, and others. Defeat in war similarly endangers the powerful along with the disempowered. in many other contexts, however, vulnerability remains closely tied to socio-economic circumstances, so that inequalities persist in the ability of social groups and individuals to defend themselves against risk. 'Risk', on this account, is not a matter of simple probabilities, to be rationally calculated by experts and avoided in accordance with the cold arithmetic of cost-benefit analysis (for a pre-eminent example of the calculative approach see Graham and Wiener 1995). Rather, it is part of the modern human condition, woven into the very fabric of progress. t he problem we urgently face is how to live democratically and at peace with the knowledge that our societies are inevitably 'at risk'. Critically important questions of risk management cannot be addressed by technical experts with conventional tools of prediction. Such questions determine not only whether we will get sick or die, and under what conditions, but also who will be affected and how we should live with uncertainty and ignorance. Is it sufficient, for instance, to assess technology's consequences, or must we also seek to evaluate its aims? How should we act when the values of scientific inquiry appear to conflict with other fundamental social values? h as our ability to innovate in some areas run unacceptably ahead of our powers of control?[1] Will some of our most revolutionary technologies increase inequality, promote violence, threaten cultures, or harm the environment? And are our institutions, whether national or supranational, up to the task of governing our dizzying technological capabilities?

To answer questions such as these, the task of managing technologies has to go far beyond the model of 'speaking truth to power' that once was thought to link knowledge to political action.[2] a ccording to this template, technical input to policy problems has to be developed independently of political influences; the 'truth' so generated acts as a constraint, perhaps the most important one, on subsequent exercises of political power. t he accidents and troubles of the late twentieth century, however, have called into question the validity of this model – either as a descriptively accurate rendition of the ways in which experts relate to policy-makers, or as a normatively acceptable formula for deploying specialized knowledge within democratic political systems (see, in particular, Jasanoff 1990). There is growing awareness that even technical policy-making needs to get more political – or, more accurately, to be seen more explicitly in terms of its political foundations. a cross a widening range of policy choices, technological cultures must learn to supplement

1 Never far from the minds of philosophers and authors of fiction, these concerns have also been famously articulated in recent times by Bill Joy, co-founder and chief scientist of Sun Microsystems. See Joy (2000).

2 t he *locus classicus* of this view of the right relations between knowledge and power is Donald K. Price's *The Scientific Estate*. See Price (1965).

the expert's preoccupation with measuring the costs and benefits of innovation with greater attentiveness to the politics of science and technology.

e ncouragingly, the need for reform in governing science and technology has been acknowledged by political authority. In the millennial year 2000, for example, the House of Lords Select Committee on Science and Technology (2000) in Britain issued a report on science and society that began with the ominous observation that relations between the two had reached a critical phase. t he authors foresaw damaging consequences for science and technology if these conditions were allowed to persist.

t his observation was widely attributed to Britain's particular experience with BSE, but the crisis of confidence *vis-à-vis* the management of science and technology has spread significantly wider. The European Union's 2001 White Paper on Governance drew on the activities of a working group on 'Democratizing e xpertise', whose report promised new guidelines 'on the collection and use of expert advice in the Commission to provide for the accountability, plurality and integrity of the expertise used' (Commission of the e uropean Communities 2001: 19). The intense worldwide discussion of the risks, benefits, and social consequences of biotechnology that began in the late 1990s can be seen as sharing many of the same concerns.

These initiatives and debates reflect a new-found interest on the part of scientists, governments, and many others in creating greater *accountability* in the production and use of scientific knowledge. The conduct of research has changed in ways that demand increased recognition. a s captured by the 'm ode 2' rubric, the pursuit of science is becoming more dispersed, context-dependent, and problem-oriented. Given these shifts, concerns with the assurance of quality and reliability in scientific production, reflecting the dominance of the 'speaking truth to power' model, are now seen as too narrowly focused. t he wider public responsibilities of science, as well as changes in modes of knowledge-making, demand new forms of public justification. Accountability can be defined in different ways, depending on the nature and context of scientific activity – for example, in demands for precaution in environmental assessments, or in calls for bioethical guidelines in relation to new genetic technologies.

Whatever its specific articulation, however, accountability in one or another form is increasingly seen as an independent criterion for evaluating scientific research and its technological applications, supplementing more traditional concerns with safety, efficacy, and economic efficiency. But how can ideas of accountability be mapped onto well-entrenched relations between knowledge and power, or expertise and public policy? t he time is ripe for seriously re-evaluating existing models and approaches. h ow have existing institutions conceptualized the roles of technical experts, decision-makers, and citizens with respect to the uses and applications of knowledge? How should these understandings be modified in response to three decades of research on the social dimensions of science? Can we respond to the demonstrated fallibility and incapacity of decision-making institutions, without abandoning hopes for improved health, safety, welfare, and social justice? Can we imagine new institutions, processes, and methods for restoring to the playing field of governance some of the normative questions that were sidelined in celebrating the benefits of technological progress? And are there structured means for deliberating and reflecting on technical matters, much as the expert analysis of risks has been cultivated for many decades?

t here is a growing need, i shall argue, for what we may call the 'technologies of humility'. t hese are methods, or better yet institutionalized habits of thought, that try to come to grips with the ragged fringes of human understanding – the unknown, the uncertain, the ambiguous, and the uncontrollable. Acknowledging the limits of prediction and control, technologies of humility confront 'head-on' the normative implications of our lack of perfect foresight. They call for different expert capabilities and different forms of engagement between experts, decision-makers, and the public than were considered needful in the governance structures of high modernity. They require not only the formal mechanisms of participation but also an intellectual environment in which citizens are encouraged to bring their knowledge and skills to bear on the resolution of common problems. Following a brief historical account, I will offer a framework for developing this approach.

t he post-war social contract

In the US, the need for working relationships between science and the state was famously articulated not by a social theorist or sociologist of knowledge, but by a quintessential technical expert: Vannevar Bush, the distinguished MIT engineer and presidential adviser. Bush (1945) foresaw the need for permanent changes following the mobilization of science and technology during the Second World War. in 1945, he produced a report, *Science – The Endless Frontier*, that was later hailed as laying the basis for a merican policy in science and technology. Science, in Bush's vision, was destined to enjoy government patronage in peacetime as it had during the war. Control over the scientific enterprise, however, would be wrested from the military and lodged with the civilian community. Basic research, uncontaminated by industrial application or government policy, would thrive in the free air of universities. Scientists would establish the substantive aims as well as the intellectual standards of research. Bush believed that bountiful results flowing from their endeavours would translate in due course into beneficial technologies, contributing to the nation's prosperity and progress. a lthough his design took years to materialize, and even then was only imperfectly attained, the US National Science Foundation (NSF) emerged as a principal sponsor of basic research.[3] t he exchange of government funds and autonomy in return for

3 The creation of the National Institutes of Health (NIH) to sponsor biomedical research divided u S science policy in a way not contemplated by Bush's original design. in the recent politics of science, NIH budgets have proved consistently easier to justify than appropriations for other branches of science.

discoveries, technological innovations, and trained personnel came to be known as a merica's 'social contract for science'.

t he Bush report said little about how basic research would lead to advances in applied science or technology. t hat silence itself is telling. it was long assumed that the diffusion of fundamental knowledge into application was linear and unproblematic. The physical system that gripped the policy-maker's imagination was the pipeline. With technological innovation commanding huge rewards in the marketplace, market considerations were deemed sufficient to drive science through the pipeline of research and development into commercialization. State efforts to promote science could then be reasonably restricted to support for basic or 'curiosity-driven' research. Simplistic in its understanding of the links between science and technology, this scheme, we may note, provided no conceptual space for the growing volume of scientific activity required to support and legitimate the multiple undertakings of modern states in the late twentieth century. In a host of areas, ranging from the environmental policy to mapping and sequencing the human genome, governmental funds have been spent on research that defies any possible demarcation between basic and applied. Yet, for many years after the war, the basic–applied distinction remained the touchstone for distinguishing work done in universities from that done in industries, agricultural experiment stations, national laboratories, and other sites concerned primarily with the uses of knowledge.

As long as the 'social contract' held sway, no-one questioned whether safeguarding the autonomy of scientists was the best way to secure the quality and productivity of basic research. Peer review was the instrument that scientists used for self-regulation as well as quality control. This ensured that state-sponsored research would be consistent with a discipline's priorities, theories, and methods. Peer review was responsible, with varying success, for ensuring the credibility of reported results, as well as their originality and interest.

So strong was the faith in peer review that policy-makers, especially in the US, often spoke of this as the best means of validating scientific knowledge, even when it was produced and used in other contexts – for example, for the purpose of supporting regulatory policy. in practice, a more complex, tripartite approach to quality control developed in most industrial democracies – peer review by disciplinary colleagues in basic science; the development of good laboratory practices, under applicable research protocols, such as products-testing or clinical trials in applied research; and risk assessment for evaluating the health or environmental consequences of polluting emissions and industrial products. But as the importance of testing, clinical research, and risk assessment grew, so, too, did calls for ensuring their scientific reliability. Once again, peer review – or its functional analogue, independent expert advice – were the mechanisms that governments most frequently used for legitimation.

Signs of wear and tear in the 'social contract' began appearing in the 1980s. a spate of highly-publicized cases of alleged fraud in science challenged the reliability of peer review and, with it, the underlying assumptions concerning the autonomy of science. t he idea of science as a unitary practice also began to break down as it became clear that research varies from one context to another, not only across disciplines, but – even more important from a policy standpoint – across institutional settings. it was recognized, in particular, that regulatory science, produced to support governmental efforts to guard against risk, was fundamentally different from research driven by scientists' collective curiosity. a t the same time, observers began questioning whether the established categories of basic and applied research held much meaning in a world where the production and uses of science were densely connected to each other, as well as to larger social and political consequences (for reviews of the extensive relevant literatures, see Jasanoff et al. 1995). The resulting effort to reconceptualize the framework of science–society interactions forms an important backdrop to present attempts to evaluate the accountability of scientific research.

Science in society: New assessments

Rethinking the relations of science has generated three major streams of analysis. The first stream takes the 'social contract' for granted, but points to its failure to work as its proponents had foreseen. Many have criticized science, especially university-based science, for deviating from idealized, m ertonian norms of purity and disinterestedness. Despite (or maybe because of) its conceptual simplicity, this critique has seriously threatened the credibility of researchers and their claim to autonomy.

o ther observers have tried to replace the dichotomous division of *basic* and *applied* science with a more differentiated pattern, calling attention to the particularities of science in different settings and in relation to different objectives. Still others have made ambitious efforts to re-specify how scientific knowledge is actually produced. This last line of analysis seeks not so much to correct or refine Vannevar Bush's vision of science, as to replace it with a more complex account of how knowledge-making fits into the wider functioning of society. Let us look at each of these three critiques.

Deviant science

Scientific fraud and misconduct became an issue on the US policy agenda in the 1980s. Political interest reached a climax with the notorious case of alleged misconduct in an mit laboratory headed by n obel laureate biologist David Baltimore. He and his colleagues were exonerated, but only after years of inquiry, which included investigations by Congress and the FBI (Kevles 1998). This and other episodes left residues in the form of greatly-increased Federal powers for the supervision of research, and a heightened tendency for policy-makers and the public to suspect that all was not in order in the citadels of basic science. Some saw the so-called 'Baltimore affair' as a powerful sign that legislators were no longer content with the old social contract's simple *quid pro quo* of money and autonomy in exchange for technological benefits (Guston 2001). Others, like the seasoned science journalist Daniel Greenberg, accused scientists of profiting immoderately from their alliance with the state, while failing to exercise moral authority or meaningful influence on policy (Greenberg 2001). American science has since been asked to justify more explicitly the public money spent on it. A token of the new relationship came with the reform of NSF's peer review criteria in the 1990s. The Foundation now requires reviewers to assess proposals not only on grounds of technical merit, but also with respect to wider social implications – thus according greater prominence to social utility. in effect, the very public fraud investigations of the previous decade opened up taken-for-granted aspects of scientific autonomy, and forced scientists to account for their objectives, as well as to defend their honesty.

t o these perturbations may be added a steady stream of challenges to the supposed disinterestedness of academic science. From studies in climate change to biotechnology, critics have accused researchers of having sacrificed objectivity in exchange for grant money or, worse, equity interests in lucrative start-up companies (see, for example Boehmer-Christiansen 1994a, 1994b). These allegations have been especially damaging to biotechnology, which benefits significantly from the rapid transfer of skills and knowledge. Since most Western governments are committed to promoting such transfers, biotechnology is caught on the horns of a very particular dilemma: how to justify its promises of innovation and progress credibly when the interests of most scientists are unacceptably aligned with those of industry, government, or – occasionally – 'public interest' advocates.

Predictably, pro-industry bias has attracted the most criticism, but academic investigators have also come under scrutiny for alleged proenvironment and anti-technology biases. in several cases involving biotechnology – in particular, that of the monarch butterfly study conducted by Cornell University scientist John Losey in the US (Losey et al. 1999), and Arpad Pusztai's controversial rat-feeding study in the UK (Stanley and Pusztai 1999) – industry critics have questioned the quality of university-based research, and have implied that political orientations may have prompted the premature release or over-interpretation of results. in a pril 2002, another controversy of this sort erupted over an article in *Nature* by a u niversity of California scientist, ignacio Chapela, who concluded that Dna from genetically modified corn had contaminated native species in Mexico. Philip Campbell, the journal's respected editor, did not retract the paper, but stated that 'the evidence available is not sufficient to justify publication' of the original paper, and that readers should judge the science for themselves (Palevitz 2002). As in the Losey and Pusztai cases, critics charged that Chapela's science had been marred by non-scientific considerations.

e nvironmentalists, however, have viewed all these episodes as pointing to wholesale deficits in knowledge about the long-term and systemic effects of genetic modification in crop plants.

Context-specific science

The second line of attack on the science-society relationship focuses on the 'basic–applied' distinction. One attempt to break out of the simplistic dualism was proposed by the late Donald Stokes, whose quadrant framework, using Louis Pasteur as the prototype, suggested that 'basic' science can be done within highly 'applied' contexts (Stokes 1997). Historians and sociologists of science and technology have long observed that foundational work can be done in connection with applied problems, just as applied problem-solving is often required for resolving theoretical issues (for example, in the design of new scientific instruments). To date, formulations based on such findings have been slow to take root in policy cultures. The interest of Stokes' work lay not so much in the novelty of his insights as in his attempt to bring historical facts to bear on the categories of science policy analysis.

Like Vannevar Bush, Stokes was more interested in the promotion of innovation than in its control. h ow to increase the democratic supervision of science was not his primary concern. n ot surprisingly, the accountability of science has emerged as a stronger theme in studies of risk and regulation, the arena in which governments seek actively to manage the potentially harmful aspects of technological progress. Here, too, one finds attempts to characterize science as something more than 'basic' or 'applied'.

From their background in the philosophy of science, Funtowicz and Ravetz (1992) proposed to divide the world of policy-relevant science into three nested circles, each with its own system of quality control: (1) 'normal science' (borrowing the well-known term of Thomas Kuhn), for ordinary scientific research; (2) 'consultancy science', for the application of available knowledge to well-characterized problems; and (3) 'post-normal science', for the highly-uncertain, highly-contested knowledge needed for many health, safety, and environmental decisions. t hese authors noted that, while traditional peer review may be effective within 'normal' and even 'consultancy' science, the quality of 'post-normal' science cannot be assured by standard review processes alone. instead, they proposed that work of this nature be subjected to *extended peer review*, involving not only scientists but also the stakeholders affected by the use of science. Put differently, they saw accountability, rather than mere quality control, as the desired objective when science becomes 'post-normal'.

Jasanoff's 1990 study of expert advisory committees in the u S noted that policy-relevant science (also referred to as 'regulatory science') – such as science done for purposes of risk assessment – is often subjected to what policy-makers call 'peer review'. o n inspection, this exercise differs fundamentally from the review of science in conventional research settings. r egulatory science is reviewed by multidisciplinary committees rather than by individually selected specialists. t he role of such bodies is not only to validate the methods by which risks are identified and investigated, but also to confirm the reliability of the agency's interpretation of the evidence (Jasanoff 1990). Frequently, regulatory science confronts the need to set standards for objects or concepts whose very existence has not previously been an issue for either science or public policy: ‘fine particulate matter’ in air pollution control; the ‘maximum tolerated dose’ (MTD) in bioassays; the ‘maximally-exposed person’ in relation to airborne toxics; or the ‘best available technology’ in many programmes of environmental regulation.

In specifying how such terms should be defined or characterized, advisory committees have to address issues that are technical as well as social, scientific as well as normative, regulatory as well as metaphysical. What *kind* of entity, after all, is a ‘fine’ particulate or a ‘maximally-exposed’ person, and by what markers can we recognize them? Studies of regulatory science have shown that the power of advisory bodies definitively to address such issues depends on their probity, representativeness, transparency, and accountability to higher authority – such as courts and the public. in other words, the credibility of regulatory science ultimately rests upon factors that have more to do with accountability in terms of democratic politics, than with the quality of science as assessed by scientific peers.

in modern industrial societies, studies designed to establish the safety or effectiveness of new technologies are frequently delegated to producers. Processes of quality control for product testing within industry include the imposition and enforcement of good laboratory practices, under supervision by regulatory agencies and their scientific advisers. The precise extent of an industry’s knowledge-producing burden is often negotiated with the regulatory agencies, and may be affected by economic and political considerations that are not instantly apparent to outsiders (setting MTDs for bioassays is one well-known example). Resource limitations may curb state audits and inspections of industry labs, leading to problems of quality control, while provisions exempting confidential trade information from disclosure may reduce the transparency of productor process-specific research conducted by industry. Finally, the limits of the regulator’s imagination place significant limitations on an industry’s duty to generate information. Only in the wake of environmental disasters involving dioxin, methyl isocyanate, and PCBs, and only after the accidental exposure of populations and ecosystems, were gaps discovered in the information available about the chronic and long-term effects of many hazardous chemicals. Before disaster struck, regulators did not appreciate the need for such information. Occurrences like these have led to demands for greater public accountability in the science that is produced to support regulation.

New modes of knowledge production

Going beyond the quality and context-dependency of science, some have suggested that we need to take a fresh look at the structural characteristics of science in order to make it more socially responsive. Michael Gibbons and his co-authors have concluded that the traditional disciplinary science of Bush’s ‘endless frontier’ has been largely supplanted by a new ‘Mode 2’ of knowledge production (Gibbons et al. 1994). The salient properties of this new Mode, in their view, include the following:

- Knowledge is increasingly produced in contexts of application (i.e., *all* science is to some extent ‘applied’ science);
- Science is increasingly transdisciplinary – that is, it draws upon and integrates empirical and theoretical elements from a variety of fields;
- Knowledge is generated in a wider variety of sites than ever before, not just in universities and industry, but also in other sorts of research centres, consultancies, and think-tanks; and
- Participants in science have grown more aware of the social implications of their work (i.e., more ‘reflexive’), just as publics have become more conscious of the ways in which science and technology affect their interests and values.

t he growth of ‘m ode 2’ science, as g ibbons et al. note, has necessary implications for quality control. Besides old questions about the intellectual merits of their work, scientists are being asked to answer questions about marketability, and the capacity of science to promote social harmony and welfare. a ccordingly:

Quality is determined by a wider set of criteria, which reflects the broadening social composition of the review system. t his implies that ‘good science’ is more difficult to determine. Since it is no longer limited to the judgments of disciplinary peers, the fear is that control will be weaker and result in lower quality work. Although the quality control process in Mode 2 is more broadly based, it does not follow . . . that it will necessarily be of lower quality (Gibbons et al. 1994: 8).

One important aspect of this analysis is that, in ‘Mode 2’ science, quality control has for practical purposes merged with accountability. g ibbons et al. view all of science as increasingly more embedded in, and hence more accountable to, society at large. To keep insisting upon a separate space for basic research, with autonomous measures for quality control, appears, within their framework, to be a relic of an earlier era.

In a more recent work, Helga Nowotny, Peter Scott, and Michael Gibbons have grappled with the implications of these changes for the production of knowledge in public domains (Nowotny et al. 2001). Unlike the ‘pipeline model’, in which science generated by independent research institutions eventually reaches industry and government, Nowotny et al. propose the concept of ‘socially robust knowledge’ as the solution to problems of conflict and uncertainty. Contextualization, in their view, is the key to producing science for public ends. Science that draws strength from its socially detached position is too frail to meet the pressures placed upon it by contemporary societies. Instead, they imagine forms of knowledge that would gain robustness from their very embeddedness in society. t he problem, of course, is how to institutionalize polycentric, interactive, and multipartite processes of knowledge-making within institutions that have worked for decades at keeping expert knowledge away from the vagaries of populism and politics. The question confronting the governance of science is how to bring knowledgeable publics into the front-end of scientific and technological production – a place from which they have historically been strictly excluded.

t he participatory turn

Changing modes of scientific research and development provide at least a partial explanation for the current interest in improving public access to expert decision-making. In thinking about research today, policy-makers and the public inevitably focus on the accountability of science. a s the relations of science have become more pervasive, dynamic, and heterogeneous, concerns about the integrity of peer review have transmuted into demands for greater public involvement in assessing the costs and benefits, as well as the risks and uncertainties, of new technologies. Such demands have arisen with particular urgency in the case of biotechnology, but they are by no means limited to that field.

t he pressure for accountability manifests itself in many ways, of which the demand for greater transparency and participation is perhaps most prominent. o ne notable example came with u S Federal legislation in 1998, pursuant to the Freedom of Information Act, requiring public access to all scientific research generated by public funds.[4] t he provision was hastily introduced and scarcely debated. Its sponsor, Senator Richard Shelby (R-Alabama), tacked it on as a last-minute amendment to an omnibus appropriations bill. His immediate objective was to force disclosure of data by the h arvard School of Public h ealth from a controversial study of the health effects of human exposure to fine particulates. This so-called 'Six Cities Study' provided key justification for the US Environmental Protection a gency's stringent ambient standard for airborne particulate matter, issued in 1997. Whatever its political motivations, this sweeping enactment showed that Congress was no longer willing to concede unchecked autonomy to the scientific community in the collection and interpretation of data, especially when the results could influence costly regulatory action. Publicly-funded science, Congress determined, should be available at all times to public review.

Participatory traditions are less thoroughly institutionalized in e uropean policy-making, but recent changes in the rules governing expert advice display a growing commitment to involving the public in technically-grounded decisions. in announcing the creation of a new Directorate g eneral for Consumer Protection, the European Commission observed in 1997 that, 'Consumer confidence in the legislative activities of the eu is conditioned by the *quality and transparency* of the scientific advice and its use on the legislative and control process' (European Commission 1997: 183, emphasis added). A commitment to greater openness is also evident in several new u K expert bodies, such as the Food Standards a gency, created to restore confidence in the wake of the BSE crisis. Similarly, two major public inquiries – the Phillips Inquiry on BSE and the Smith Inquiry on the Harold Shipman murder investigation – set high standards for public access to information

4 Public Law 105–277 (1998). The Office of Management and Budget in the Clinton administration controversially narrowed the scope of the law to apply not to *all* publicly funded research, but only to research actually relied upon in policy-making. The issue is not completely resolved as of this writing.

through the Internet. All across Europe, opposition to genetically-modified foods and crops has prompted experiments with diverse forms of public involvement, such as citizen juries, consensus conferences, and referenda (Joss and Durant 1995).

a lthough these efforts are admirable, formal participatory opportunities cannot by themselves ensure the representative and democratic governance of science. t here are, to start with, practical problems. People may not possess enough specialized knowledge and material resources to take advantage of formal procedures. Participation may occur too late to identify alternatives to dominant or default options; some processes, such as consensus conferences, may be too *ad hoc* or issue-specific to exercise sustained influence. More problematic is the fact that even timely participation does not necessarily improve decision-making. e mpirical research has consistently shown that transparency may exacerbate rather than quell controversy, leading parties to deconstruct each other's positions instead of deliberating effectively. Indeed, the Shelby Amendment reflects one US politician's conviction that compulsory disclosure of data will enable any interested party to challenge researchers' interpretations of their work. Participation, in this sense, becomes an instrument to challenge scientific points on political grounds. By contrast, public participation that is constrained by established formal discourses, such as risk assessment, may not admit novel viewpoints, radical critiques, or considerations lying outside the taken-for-granted framing of the problem. While national governments are scrambling to create new participatory forms, there are signs that such changes may reach neither far enough nor deeply enough to satisfy the citizens of a globalizing world. Current reforms leave out public involvement in corporate decision-making at the design and product-development phases. The m onsanto Company's experience with the 't erminator gene' suggests that political activists may seize control of decisions on their own terms, unless governance structures provide for more deliberative participation. in this case, the mere possibility that a powerful multinational corporation might acquire technology to deprive poor farmers of their rights, galvanized an activist organization – r ural Advancement Foundation International (RAFI) – to launch an effective worldwide campaign against the technology.[5] t hrough a combination of inspired media tactics (including naming the technology after a popular science-fiction movie) and strategic alliance-building (for example, with the Rockefeller Foundation), RAFI forced Monsanto to back down from this particular product. The episode

5 In 1998, a small cotton seed company called Delta and Pine Land (D&PL) patented a technique designed to switch off the reproductive mechanism of agricultural plants, thereby rendering their seed sterile. t he company hoped that this technology would help protect the intellectual property rights of agricultural biotechnology firms by taking away from farmers the capacity to re-use seed from a given year's genetically modified crops in the next planting season. While the technology was still years away from the market, rumours arose of a deal by Monsanto to acquire D&PL. This was the scenario that prompted RAFI to act. See Service (1998).

can be read as a case of popular technology assessment, in a context where official processes failed to deliver the level of accountability desired by the public.

Participation alone, then, does not answer the problem of how to democratize technological societies. o pening the doors to previously closed expert forums is a necessary step – indeed, it should be seen by now as a standard operating procedure. But the formal mechanisms adopted by national governments are not enough to engage the public in the management of global science and technology. What has to change is the *culture* of governance, within nations as well as internationally; and for this we need to address not only the mechanics, but also the substance of participatory politics. t he issue, in other words, is no longer *whether* the public should have a say in technical decisions, but *how* to promote more meaningful interaction among policy-makers, scientific experts, corporate producers and the public.

t echnologies of humility

The analytic ingenuity of modern states has been directed toward refining what we may call the 'technologies of hubris'. To reassure the public, and to keep the wheels of science and industry turning, governments have developed a series of predictive methods (e.g., risk assessment, cost-benefit analysis, climate modelling) that are designed, on the whole, to facilitate management and control, even in areas of high uncertainty (see, for example, Porter 1995). These methods achieve their power through claims of objectivity and a disciplined approach to analysis, but they suffer from three significant limitations. First, they show a kind of peripheral blindness toward uncertainty and ambiguity. Predictive methods focus on the known at the expense of the unknown, producing overconfidence in the accuracy and completeness of the pictures they produce. Well-defined, short-term risks command more attention than indeterminate, long-term ones, especially in cultures given to technological optimism. At the same time, technical proficiency conveys the false impression that analysis is not only rigorous, but complete – in short, that it has taken account of all possible risks. Predictive methods tend in this way to downplay what falls outside their field of vision, and to overstate whatever falls within.

Second, the technologies of predictive analysis tend to pre-empt political discussion. Expert analytic frameworks create high entry barriers against legitimate positions that cannot express themselves in terms of the dominant discourse (irwin and Wynne 1996). Claims of objectivity hide the exercise of judgment, so that normative presuppositions are not subjected to general debate. The boundary work that demarcates the space of 'objective' policy analysis is carried out by experts, so that the politics of demarcation remains locked away from public review and criticism (Jasanoff 1990).

t hird, predictive technologies are limited in their capacity to internalize challenges that arise outside their framing assumptions. For example, techniques for assessing chemical toxicity have become ever more refined, but they continue to rest on the demonstrably faulty assumption that people are exposed to one chemical at a time. Synergistic effects, long term exposures, and multiple exposures are common in normal life, but have tended to be ignored as too messy for analysis – hence, as irrelevant to decision-making. Even in the aftermath of catastrophic failures, modernity's predictive models are often adjusted to take on board only those lessons that are compatible with their initial assumptions. When a u S-designed chemical factory in Bhopal released the deadly gas methyl isocyanate, killing thousands, the international chemical industry made many improvements in its internal accounting and risk-communication practices. But no new methods were developed to assess the risks of technology transfer between radically different cultures of industrial production.

To date, the unknown, unspecified, and indeterminate aspects of scientific and technological development remain largely unaccounted for in policy-making; treated as beyond reckoning, they escape the discipline of analysis. Yet, what is lacking is not just knowledge to fill the gaps, but also processes and methods to elicit what the public wants, and to use what is already known. To bring these dimensions out of the shadows and into the dynamics of democratic debate, they must first be made concrete and tangible. Scattered and private knowledge has to be amalgamated, perhaps even disciplined, into a dependable civic epistemology. The human and social sciences of previous centuries undertook just such a task of translation. t hey made visible the social problems of modernity – poverty, unemployment, crime, illness, disease, and lately, technological risk – often as a prelude to rendering them more manageable, using what i have termed the 'technologies of hubris'. t oday, there is a need for 'technologies of humility' to complement the predictive approaches: to make apparent the possibility of unforeseen consequences; to make explicit the normative that lurks within the technical; and to acknowledge from the start the need for plural viewpoints and collective learning. h ow can these aims be achieved? From the abundant literature on technological disasters and failures, as well as from studies of risk analysis and policy-relevant science, we can abstract four focal points around which to develop the new technologies of humility. t hey are *framing*, *vulnerability*, *distribution*, and *learning*. Together, they provide a framework for the questions we should ask of almost every human enterprise that intends to alter society: what is the purpose; who will be hurt; who benefits; and how can we know? On all these points, we have good reason to believe that wider public engagement would improve our capacity for analysis and reflection. Participation that pays attention to these four points promises to lead neither to a hardening of positions, nor to endless deconstruction, but instead to richer deliberation on the substance of decision-making.

Framing

It has become an article of faith in the policy literature that the quality of solutions to perceived social problems depends on the way they are framed (Schön and r ein

1994). If a problem is framed too narrowly, too broadly, or wrongly, the solution will suffer from the same defects. To take a simple example, a chemical-testing policy focused on single chemicals cannot produce knowledge about the environmental health consequences of multiple exposures. The framing of the regulatory issue is more restrictive than the actual distribution of chemical-induced risks, and hence is incapable of delivering optimal management strategies. Similarly, a belief that violence is genetic may discourage the search for controllable social influences on behaviour. A focus on the biology of reproduction may delay or impede effective social policies for curbing population growth. When facts are uncertain, disagreements about the appropriate frame are virtually unavoidable and often remain intractable for long periods. Yet, few policy cultures have adopted systematic methods for revising the initial framing of issues (Stern and Fineburg 1996). Frame analysis thus remains a critically important, though neglected, tool of policy-making that would benefit from greater public input (see Nisbet, this volume).

Vulnerability

Risk analysis treats the ‘at-risk’ human being as a passive agent in the path of potentially disastrous events. in an effort to produce policy-relevant assessments, human populations are often classified into groups (e.g., most susceptible, maximally exposed, genetically predisposed, children or women) that are thought to be differently affected by the hazard in question. Based on physical and biological indicators, however, these classifications tend to overlook the social foundations of vulnerability, and to subordinate individual experiences of risk to aggregate numerical calculations (for some examples, see Irwin and Wynne 1996). r ecent efforts to analyse vulnerability have begun to recognize the importance of socio-economic factors, but methods of assessment still take populations rather than individuals as the unit of analysis. t hese approaches not only disregard differences within groups, but reduce individuals to statistical representations. Such characterizations leave out of the calculus of vulnerability such factors as history, place, and social connectedness, all of which may play crucial roles in determining human resilience. t hrough participation in the analysis of their vulnerability, ordinary citizens may regain their status as active subjects, rather than remaining undifferentiated objects in yet another expert discourse.

Distribution

Controversies over such innovations as genetically modified foods and stem cell research have propelled ethics committees to the top of the policy-making ladder. Frequently, however, these bodies are used as ‘end-of-pipe’ legitimation devices, reassuring the public that normative issues have not been omitted from governmental deliberation. t he term ‘ethics’, moreover, does not cover the whole range of social and economic realignments that accompany major technological changes, nor their distributive consequences, particularly as technology unfolds across global societies and markets. Attempts to engage systematically with distributive issues in policy processes have not been altogether successful. in e urope, consideration of the 'fourth hurdle' – the socioeconomic impact of biotechnology – was abandoned after a brief debate.

In the US, the congressional Office of Technology Assessment, which arguably had the duty to evaluate socio-economic impacts, was dissolved in 1995 (Bimber 1996). President Clinton's 1994 injunction to Federal agencies to develop strategies for achieving environmental justice has produced few dramatic results (Clinton 1994). At the same time, episodes like the RAFI-led rebellion against Monsanto demonstrate a deficit in the capacity for ethical and political analysis in large corporations, whose technological products can fundamentally alter people's lives. Sustained interactions between decision-makers, experts, and citizens, starting at the upstream end of research and development, could yield significant dividends in exposing the distributive implications of innovation.

Learning

t heorists of social and institutional learning have tended to assume that what is 'to be learned' is never part of the problem. a correct, or at least a better, response exists, and the issue is whether actors are prepared to internalize it. in the social world, learning is complicated by many factors. t he capacity to learn is constrained by limiting features of the frame within which institutions must act. institutions see only what their discourses and practices permit them to see. Experience, moreover, is polysemic, or subject to many interpretations, no less in policy-making than in literary texts. Even when the fact of failure in a given case is more or less unambiguous, its causes may be open to many different readings.

Just as historians disagree over what may have caused the rise or fall of particular political regimes, so policy-makers may find it impossible to attribute their failures to specific causes. The origins of a problem may appear one way to those in power, and quite another way to the marginal or the excluded. Rather than seeking monocausal explanations, it would be fruitful to design avenues through which societies can collectively reflect on the ambiguity of their experiences, and to assess the strengths and weaknesses of alternative explanations. Learning, in this modest sense, is a suitable objective of civic deliberation.

Conclusion

t he enormous growth and success of science and technology during the last century has created contradictions for institutions of governance. a s technical activities have become more pervasive and complex, demand has grown for more complete and multivalent evaluations of the costs and benefits of technological progress. It is widely recognized that increased participation and interactive knowledge-making may improve accountability and lead to more credible assessments of science and technology.

Such approaches will also be consistent with changes in the modes of knowledge production, which have made science more socially embedded and more closely tied to contexts of application. Yet, modern institutions still operate with conceptual models that seek to separate science from values, and that emphasize prediction and control at the expense of reflection and social learning. Not surprisingly, the real world continually produces reminders of the incompleteness of our predictive capacities through such tragic shocks as Perrow's 'normal accidents'. a promising development is the renewed attention being paid to participation and transparency. Such participation, i have argued, should be treated as a standard operating procedure of democracy, but its aims must be considered as carefully as its mechanisms. Formally constituted procedures do not necessarily draw in all those whose knowledge and values are essential to making progressive policies.

Participation in the absence of normative discussion can lead to intractable conflicts of the kind encountered in the debate on policies for climate change. Nor does the contemporary policy-maker's near-exclusive preoccupation with the management and control of risk, leave much space for tough debates on technological futures, without which we are doomed to repeat past mistakes.

t o move public discussion of science and technology in new directions, i have suggested a need for 'technologies of humility', complementing the predictive 'technologies of hubris' on which we have lavished so much of our past attention. t hese *social* technologies would give combined attention to substance and process, and stress deliberation as well as analysis. r eversing nearly a century of contrary development, these approaches to decision-making would seek to integrate the 'can do' orientation of science and engineering with the 'should do' questions of ethical and political analysis. They would engage the human subject as an active, imaginative agent, as well as a source of knowledge, insight, and memory. The specific focal points I have proposed – framing, vulnerability, distribution, and learning – are pebbles thrown into a pond, with untested force and unforeseeable ripples. These particular concepts may prove insufficient to drive serious institutional change, but they can at least offer starting points for a deeper public debate on the future of science in society.

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Part II
Science Communication, Ethics and Framing: Models and Cultural Reality

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Chapter 4

t he e thics of Framing Science

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Over the past decade, among an avant-garde of US scientists, journalists, and affiliated organizations, there has been a growing recognition that scientific knowledge alone does not compel public perceptions or policymaker decisions. instead, these innovators understand that effective communication involves addressing an intended audience's values, interests, and worldviews. t his approach requires scientists and journalists to not only draw upon audience-based research to tailor messages but also to actively sponsor public dialogue and the exchange of perspectives. In this new light, science communication is no longer defined as a process of transmission, but rather as an active and ongoing conversation with a range of stakeholders.

r esearch in the area of framing has been a central driver of this paradigm shift. 'Frames' are the conceptual term for interpretative storylines that communicate what is at stake in a science-related debate and why the issue matters (Gamson and Modigliani, 1989). At a theoretical and descriptive level, framing research offers a rich explanation for how various actors in society define science-related issues in politically strategic ways, how journalists from various beats selectively cover these issues, and how diverse publics differentially perceive, understand, and participate in these debates (Pan and Kosicki, 1993; Scheufele, 1999; Nisbet 2009a). For each group, frames help simplify complex issues by lending greater weight to certain considerations and arguments over others, translating why an issue might be a problem, who or what might be responsible, and what should be done (Feree, et al., 2002). In this manner, frames provide common points of reference and meaning between science, the media, and key publics (Hellsten and Nerlich, 2008).

Perhaps even more importantly, at an applied level, this basic research can serve as an innovative public communication technology. o n issues such as climate change, evolution, and nanotechnology, studies are examining what specific groups in society want to know, their political interpretations, the perceived implications for their daily lives, the resonance or conflict with their values and social identities, where they are most likely to receive information, and who or what they are looking to for answers. When specific intended audiences have been carefully researched and understood, the resulting tailored messages can be true to the science, but also personally relevant and meaningful to a diverse array of publics. g overnment agencies, nongovernmental organizations, and science institutions can use the results of this audience research to design and plan their communication initiatives, thereby promoting public learning, empowering public participation, or moving the discussion beyond polarization and gridlock. Journalists can also use this information to craft novel, accessible, and relevant narratives for nontraditional audiences across media formats, expanding their journalistic reach and impact (see Labov and Pope, 2008; Leiserowitz, Maibach, and Roser-Renouf, 2008; Nisbet 2009b; Scheufele, 2006 for examples).

Yet, as these research-based approaches to public communication move forward, critics have argued that these innovations imperil the perceived objectivity, neutrality, and independence of scientists and journalists, while reinforcing a tradition of 'top-down' communication from experts to the public (see for example Holland et al., 2007). In this chapter, I address these concerns by outlining the ethical implications of framing as applied to science-related policy debates, focusing specifically on the normative obligations of scientists, journalists, and their affiliated organizations. Importantly, I note the key differences in ethical imperatives between these groups and other communicators in science-related policy debates, notably social critics and partisan strategists.

f our guiding principles

To begin the chapter, I briefly review how past research in political communication and sociology describes a lay public that makes sense of science-related policy debates by drawing upon a mental toolkit of cognitive short cuts and easily applied criteria. This research shows that science literacy has only a limited influence on perceptions; instead, public judgments are based on an interaction between the social background of an audience and the frames most readily available by way of the news, popular culture, social networks, and/or conversations.

Surveys indicate that a mericans strongly believe in the promise of science to improve life, deeply admire scientists, and hold science in higher esteem than almost any other institution. Scientists therefore enjoy tremendous communication capital; the challenge is to understand how to use this resource effectively and wisely. importantly, in terms of ethical obligations, one of the conclusions of this body of research is that whenever possible, *dialogue should be a focus of science communication efforts, rather than traditional top-down and one-way transmission approaches*.

I then briefly describe a deductive set of frames that apply consistently across science-related debates. Breaking 'the frame' so to speak is very difficult to do, since the interpretative resources that society draws upon to collectively make sense of science are based on shared identities, traditions, history, and culture. i also review the important differences between 'science,' 'policy,' and 'politics,' arguing that there are few cases, if any, where science points decisively to a clear policy path or where policy decisions are free from politics. in this context, scientists and journalists can be either 'issue advocates' or 'honest brokers,' and in each role, framing is central to communication effectiveness.

Yet, no matter their chosen role, *scientists and journalists should always emphasize the values-based reasons for a specific policy action*. a s i discuss, when a policy choice is simplistically defined as driven by 'sound science' or as a matter of 'inconvenient truths,' it only serves to get in the way of public engagement and consensus-building. Science becomes just another political resource for competing interest groups, with accuracy often sacrificed in favor of political victory.

indeed*, accuracy is a third ethical imperative.* n o matter their role as issue advocate or honest broker, both scientists and journalists must respect the uncertainty that is inherent to any technical question and resist engaging in hyperbole. i f these groups stray from accurately conveying what is conventionally known about an issue, they risk losing public trust.

Finally, for scientists and journalists, *a fourth ethical imperative is to avoid using framing to denigrate, stereotype, or attack a particular social group or to use framing in the service of partisan or electoral gains*. a s i review, this is particularly relevant to communicating about issues such as evolution, where pundits such as Richard Dawkins use their authority as scientists to argue their personal opinion that science undermines the validity of religion and even respect for the religious. t he ethical norm also applies to the use by partisans of stem cell research – and science generally – as a political wedge strategy in recent elections. Framing will always be an effective and legitimate part of social criticism and electoral politics, but for scientists and journalists to simplistically define critiques of religion or opposition to a candidate as a 'matter of science' only further fuels polarization, alienating key publics and jeopardizing the perceived legitimacy of science.

f raming and science policy debates

a prevailing assumption historically has been that ignorance is at the root of social conflict over science. As a solution, after formal education ends, science media and other communication methods should be used to educate the public about the technical details of the matter in dispute. o nce citizens are brought up to speed on the science, they will be more likely to judge scientific issues as scientists do and controversy will go away. In this decades-old 'deficit' model, communication is defined as a process of transmission. The facts are assumed to speak for themselves and to be interpretable by all citizens in similar ways. i f the public does not accept or recognize these facts, then the failure in transmission is blamed on journalists, 'irrational' public beliefs, or both (For more on the deficit model see, Bauer, 2008; Nisbet and Goidel, 2007; Wynne, 1992).

Yet as communication researchers will recognize, the deficit model ignores a number of realities about audiences and how they use the media to make sense of public affairs and policy debates. First, individuals are naturally 'cognitive misers' who rely heavily on mental short cuts, values, and emotions to make sense of a science-related issue. These 'shortcuts' work in place of paying close attention to news coverage of science debates and in lieu of scientific or policy-related knowledge (see Downs, 1957; Popkin, 1991). Second, as part of this miserly nature, individuals are drawn to news sources that confirm and reinforce their pre-existing beliefs. t his tendency, of course, has been facilitated by the fragmentation of the media and the rise of ideologically slanted news outlets (Mutz, 2006). Third, in a media environment with many choices, if an individual lacks a strong preference or motivation for quality science coverage, then they can completely avoid such content, instead focusing narrowly on their preferred news topics or entertainment and infotainment (Prior, 2005).

Finally, survey evidence counters deficit model claims that science has lost its position of respect and authority in a merican society. Consider that more than 85% of Americans agree that 'even if it brings no immediate benefits, scientific research that advances the frontiers of knowledge is necessary and should be supported by the federal government.' On the specific issues of climate change, stem cell research, and food biotechnology, respondents believe scientists hold greater expertise, are less self-interested, and should have greater say in decisions than industry leaders, elected officials, and/or religious leaders. Moreover, during the past twenty years, as public trust in Congress, the presidency, industry, religious institutions, and the media have plummeted, public faith in science has remained virtually unchanged. In fact, among American institutions, only the military enjoys more trust (NSB, 2008).

g iven these realities, to focus on science literacy as both the cause and the solution to conflict remains a major distraction for scientists, journalists, and advocates alike. Moreover, if scientists in particular had a better understanding of the complex factors that shape public preferences and policy decisions, they would be less likely to define every debate in terms of 'crisis' or 'politicization,' interpretations that distract from building consensus around shared values and common goals and that may actually alienate key publics (Goldston, 2008; Nisbet, 2009b).

Alternatives to the deficit model

Serious critiques of the deficit model first gained prominence in the early 1990s as sociologists used ethnographic approaches to study how particular social groups made sense of scientific expertise and authority (see Irwin and Michael, 2003 for an overview). Among these studies, Bryan Wynne and colleagues proposed a set of mental rules that lay publics are likely to use in evaluating scientific advice and expertise (CSEC, 2001; Marris, 2001; Wynne, 1992). These common sense heuristics fit closely with the conclusions from quantitative public opinion research reviewed earlier (see Nisbet and Goidel, 2007; Bauer, 2008 for more). Specifically, lay publics are likely to apply the following criteria in reaching judgments:

- Does scientific knowledge work? Do public predictions by scientists fail or prove to be true?

- Do scientific claims pay attention to other available knowledge? For example, in understanding the risks to the food supply from the 1986 Chernobyl disaster, did scientists consult with farmers on how to best monitor grazing habits and take samples from livestock?
- a re scientists open to criticism? a re they willing to admit errors and oversights?
- What are the social and institutional affiliations of scientists? In other words, do they have a historical track record of trustworthiness? Similarly, do they have perceived conflicts of interest relative to their associations with industry, government, universities, or advocacy groups?
- What other issues overlap or connect to a public's immediate perception of the scientific issue? In the UK debate over genetically modified food, both Chernobyl and mad cow disease served as recent events that undermined public trust in government claims about risk.
- Specific to risks, have potential long-term and irreversible consequences of science been seriously evaluated, and by whom? a nd do regulatory authorities have sufficient powers to effectively regulate organizations and companies who wish to develop the science? Who will be held responsible in cases of unforeseen harm?

In 2000, drawing upon this emerging body of work, a UK House of Lords report urged science institutions to move beyond just a one-way transmission model of science communication towards a new focus on deliberative contexts where a variety of stakeholders could participate in a dialogue and exchange of views about science policy. o ver the past decade, in the u K, e urope, and Canada there has been a wave of consensus conferences, deliberative forums, and town meetings on a number of issues. In these initiatives, recruited lay participants receive background materials in advance, provide input on the types of questions they would like addressed at the meeting, and then provide direct input on recommendations about what should be done in terms of policy. e ach initiative, however, varies by how participants are asked for feedback, how much their feedback matters, and exactly when in the development of a scientific debate consultation occurs (Einsiedel, 2008).

Through these initiatives, studies find that participants not only learn directly about the technical aspects of the science involved, but perhaps more importantly, they also learn about the social, ethical, and economic implications of the scientific topic. Participants also feel more confident and empowered about their ability to participate in science decisions, perceive relevant institutions as more responsive to their concerns, and say that they are motivated to become active on the issue if provided a future opportunity to do so (Besley, Kramer, Yao, and t oumey, 2008; Powell and Kleinmann, 2008). Just as importantly, deliberative forums, if carefully organized, shape perceptions of scientists as open to feedback and respectful of public concerns, perceptions that predict eventual acceptance and satisfaction with a policy outcome, even if the decision is contrary to an individual's original preference (Besley and McComas, 2005; Borchelt and Hudson, 2008).

Top-down and bottom-up framing

From a normative standpoint, empowering citizens to participate in collective decisions about science-related policy is central to the functioning of a democracy, especially when citizens are expected to bear both the costs and the risks of a policy decision. Yet the major limitation to public dialogue initiatives is their small scale size and scope. u nless intensive resources are spent on recruiting a diverse set of participants, the most likely individuals to turn out are those already opinion intense, well informed, and emotionally committed to an issue (Goidel and Nisbet, 2006). a s a result, in combination with traditional science media and public consultation efforts, scientists and journalists must also learn to focus on 'framing' their messages in ways that engage wider and more diverse publics, while discovering new media platforms for reaching audiences and sponsoring dialogue.

Frames work by connecting the mental dots for the public. They suggest a connection between two concepts, issues, or things, such that after exposure to the framed message, audiences accept or are at least aware of the connection. a n issue has been successfully framed when there is a fit between the line of reasoning a message or news story suggests on an issue and the presence of those existing mental associations within a particular audience (Scheufele and Tewksbury, 2007). For example, as I will review later on climate change, by emphasizing the religious and moral dimensions of the issue, several scientists have convinced religious leaders that understanding the science of climate change is directly applicable to questions of faith. The normatively desirable outcome has been to bridge ideological divides on the issue while sponsoring learning and dialogue.

Complementing these psychological accounts, sociologists such as William g amson have promoted a 'social constructivist' explanation of framing. a ccording to this research, in order to make sense of political issues, citizens use as resources the frames available in media coverage, but integrate these packages with the frames forged by way of personal experience or conversations with others. Frames might help set the terms of the debate among citizens, but rarely, if ever, do they exclusively determine public opinion. instead, as part of a 'frame contest,' one interpretative package might gain influence because it resonates with popular culture or a series of events, fits with media routines or practices, and/or is heavily sponsored by elites (Gamson, 1992; Price, Nir, and Capella, 2005).

As Wynne (1992) has argued, many members of the public hold their own relevant lay knowledge about a science-related debate that is based on personal experience, culture, or conventional wisdom. m oreover, in combination with media coverage, these lay theories enable people to reason and talk about a complex science debate in their own familiar terms and to participate in consultation exercises such as deliberative forums (Pan and Kosicki, 2007). In other words, motivated citizens – when given the opportunity – can actively participate in a 'bottom up' framing of issues. Social movements, for example, have historically used frames to mobilize members and connect groups into advocacy coalitions (see Croteau, Hoynes, and Ryan, 2005 for an overview).

With new forms of user-centred and user-controlled digital media such as blogs, online video, and social media sites, 'bottom up' alternative frames may be gaining greater influence in the discursive contests that surround issues such as climate change or stem cell research. t herefore, one way to effectively and ethically use framing to sponsor dialogue among a wider public is to invest at the local and regional level in 'participatory digital media infrastructures' for science and environmental issues.

t his type of investment may be particularly important for the u S, where local newspapers have cut meaningful coverage of science and the environment. a s a result, many communities lack the type of relevant news and information that is needed to adapt to environmental challenges or to reach collective choices about issues such as nanotechnology and biomedical research. a s one possible way forward, government agencies and foundations can fund public television and radio organizations as community science information hubs. t hese 'public media 2.0' initiatives would partner with universities, museums, and other local media outlets to share digital content that is interactive and user-focused. t he digital portals would feature in depth reporting, blogs, podcasts, shared video, news aggregation, user recommendations, news games, social networking, and commenting. Via a mix of 'top-down' and 'bottom-up' framing of issues, these new models for non-profit science media would be an integral part of the infrastructure that local communities need to adapt to climate change, to move forward with sustainable economic development, and to participate in the governance of science, medicine, and technology (See Clark and Aufderheide, 2009 for a discussion of these new media models).

The anatomy of frames

The identification and application of frames as general organizing devices – whether as used in advocacy campaigns, in a news story, or in a digital discussion – should not be confused with specific policy positions. As Gamson and his colleagues describe, individuals can disagree on an issue but share the same interpretative frame (see Gamson and Modigliani, 1989), which means that any frame can include pro, anti, and neutral arguments (see Feree et al., 2002; Tankard, 2001). For example, as i will review, a dominant frame applied to stem cell research is that the issue is fundamentally a matter of 'morality/ethics.' Both sides use this frame to argue their case in the debate. r esearch opponents say it is morally wrong to destroy embryos, since they constitute human life. r esearch supporters say it is morally wrong to hold back on research that could lead to important cures.

The latent meaning of any frame is often translated instantaneously by specific types of framing devices such as catchphrases, metaphors, sound bites, graphics, and allusions to history, culture, and/or literature (Gamson, 1992). Many studies often confuse frames and frame devices. For example, they might track in news coverage or test in an experiment a slogan such as former u S vice president a l g ore's 'climate crisis,' but never carefully consider the underlying interpretative

t able 4.1 a typology of frames applicable to science-related policy debates

f rame	Defines science-related issue as…
Social progress	…improving quality of life, or solution to problems. Alternative interpretation as harmony with nature instead of mastery, 'sustainability.'
e conomic development/ competitiveness	…economic investment, market benefits or risks; local, national, or global competitiveness.
m orality/ethics	…in terms of right or wrong; respecting or crossing limits, thresholds, or boundaries.
Scientific/technical uncertainty	…a matter of expert understanding; what is known versus unknown; either invokes or undermines expert consensus, calls on the authority of 'sound science,' falsifiability, or peer-review.
Pandora's box/ Frankenstein's monster/ runaway science	…call for precaution in face of possible impacts or catastrophe. Out-of-control, a Frankenstein's monster, or as fatalism, i.e. action is futile, path is chosen, no turning back.
Public accountability/ governance	…research in the public good or serving private interests; a matter of ownership, control, and/or patenting of research, or responsible use or abuse of science in decision-making, 'politicization.'
m iddle way/alternative path	…around finding a possible compromise position, or a third way between conflicting/polarized views or options.
Conflict/strategy	…as a game among elites; who's ahead or behind in winning debate; battle of personalities; or groups; (usually journalist-driven interpretation.)

Note: Frame typology derived from previous analyses of nuclear energy, food and medical biotechnology, and recently applied to climate change and evolution (Dahinden, 2002; Durant, Bauer, and Gaskell, 1998; Nisbet and Lewenstein, 2002; Nisbet 2009a; Nisbet 2009b).

meaning ('runaway, impending disaster'), of which the slogan is just one among many possible triggers.

i dentifying the frames that apply to a science-related policy debate should be approached both deductively and inductively. Drawing on previous work, studies usually work from a set of frames that appear to recur across policy debates. Originally identified by Gamson and Modigliani (1989) in a framing study of nuclear energy, the typology of frames, which include for example public accountability and social progress, was further adapted in studies of food and medical biotechnology in e urope and the u nited States (Dahniden, 2002; Durant, Bauer, and Gaskell, 1998; Nisbet and Lewenstein, 2002). In Table 4.1, I outline this generalizable typology of frames, defining the latent meanings of each interpretation. (With the reader in mind, throughout the rest of the chapter, when discussing the framing of a specific issue, references to frames from the typology are italicized and frame devices are given in quotation marks.)

Communicating values rather than inconvenient truths

'Science,' broadly speaking, can be defined as the systematic pursuit of knowledge, whereas 'policy' refers to a specific decision or course of action, and 'politics' is the process of bargaining, conflict, negotiation, and compromise that determines who gets what, when, and how (Pielke, 2007). These distinctions matter to public communication and framing. The tendency of scientists, journalists, advocates, and elected officials to define policy debates as exclusively about science and not in terms of either politics or values is often at the root of political conflict and puts at risk public trust in scientific research (Bipartisan Policy Center, 2009).

in particular, if science becomes the perceived dominant reason for a course of action, then as a matter of strategy and politics, competing interests will have the incentive to claim that scientific evidence is on their side. As a consequence, an inevitable part of the framing of an issue will involve a contest over *uncertainty*, with each side potentially hyping or distorting the objective state of expert consensus. Arguing that a policy debate is simply a matter of 'sound science' reduces scientific knowledge to just another resource that interest groups can draw upon in political battles, threatening the perceived integrity of science. e ach time an exaggerated scientific claim is proven false or inaccurate, it risks further alienating publics already distrustful of the science and scientists (see Pielke, 2007 for more).

t his tendency to reduce science policy decisions down to debates over science rather than values is perhaps principally responsible in the u nited States for lingering political gridlock over climate change. To date, so-called climate sceptics continue to successfully downplay public concern by narrowly framing the issue in terms of *scientific uncertainty*. in contrast, a l g ore, many environmentalists, and even some scientists have attempted to counter the *uncertainty* frame with their own message that climate science in fact compels action, dramatizing this science by way of a *Pandora's box* emphasis on a looming 'climate crisis.'

Publicity for g ore's *An Inconvenient Truth* led with this storyline, including a movie poster with the frame device of a hurricane-shaped plume spewing from a smoke stack and a trailer that told audiences to expect 'the most terrifying film you will ever see.' With an accent on the visual and the dramatic, the catastrophe strategy triggered similarly framed news coverage. For example, a much talked about *Time* magazine cover from 2006 featured the image of a polar bear on melting ice with the tagline: 'Be worried, be Ver Y worried' (see n isbet, 2009b for an overview.)

Yet these claims are effectively challenged by climate sceptics as liberal 'alarmism,' putting the issue quickly back into the mental box of *scientific uncertainty* and partisanship. Polls suggest that the American public has picked up on these claims of 'climate exaggeration,' likely filtering them back through their preferred partisan lenses and their existing views on liberal media bias. t he result is that many otherwise well-informed a mericans increasingly discount the climate change problem, while also believing that the mainstream news media is exaggerating the issue (see Nisbet, 2009b).

A values-based second premise

An overwhelming majority of scientists have concluded that human activities are contributing to climate change and that this presents a major risk to society. Yet this scientific research – this first premise about climate change – does not offer an explicit normative framework that might guide decision-making, helping individuals decide whether action is worth the costs and trade-offs or which policy might be most in line with their values, whether religiously or secularly based. in short, the science does not speak for itself, and as survey research continues to show, this first premise of scientific certainty remains selectively interpreted by the a merican public based on their values and partisan identity.[1]

m any scientists and environmental advocates, of course, do offer an explicit second premise, though these values are probably not strongly shared by a majority of a mericans. a s a matter of *social progress* and environmental *ethics*, advocates such as Al Gore and best-selling writers such as Bill McKibbon (2008) argue that we should take action on climate change because human activities have shifted the planet into 'dangerous disequilibrium,' altering the natural order of things. n ot only is it morally wrong to violate and imperil nature but our actions threaten future generations of humans.

The challenge on climate change is to identity the specific moral framework – or second premise – that works for specific segments of the public and to effectively frame the significance of climate change as in line with that framework. For example, a 2006 'Evangelical Call to Action' succinctly lays out the first and second premise for a Christian public.[2] t he document asserts that 'human induced climate change is real' and that 'the consequences of climate change will be significant.' The document then frames the second premise, or the reason why Christians should care:

> Christians must care about climate change because we love g od the Creator and Jesus our l ord, through whom and for whom the creation was made. t his is g od's world, and any damage that we do to g od's world is an offense against God Himself (Gen. 1; Ps. 24; Col. 1:16).
>
> Christians must care about climate change because we are called to love our neighbours, to do unto others as we would have them do unto us, and to protect and care for the least of these as though each was Jesus Christ himself (m t. 22:34–40; Mt. 7:12; Mt. 25:31–46).

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1 I owe the comparison of 'communicating the first and second premise' to Oregon State University philosopher Kathleen Dean Moore, who organized a March 2009 workshop bringing together humanists, artists, social scientists, and scientists to strategize new ways of communicating 'the second premise' on climate change, or a values-based reason for action. See the Web site of The Spring Creek Project at http://springcreek.oregonstate.edu/.

2 The call to action and affiliated Web project can be found at http://christiansandclimate.org/learn/call-to-action/.

e very science policy debate, no matter how certain expert agreement, falls into the 'second premise' category. In fact, as President Barack Obama's March 2009 stem cell decision and speech makes clear, while there is often conflict and distortion over what 'consensus' might be in the scientific community, most political battles over science revolve over the normative frameworks that are the grounds for action.

In Obama's speech, he opened with the established framing playbook among stem cell advocates, defining the issue in terms of *social progress* while also being careful not to go beyond *scientific uncertainty*, avoiding past exaggerations over the realistic timeline for discoveries:

> At this moment, the full promise of stem cell research remains unknown, and it should not be overstated. But scientists believe these tiny cells may have the potential to help us understand, and possibly cure, some of our most devastating diseases and conditions. t o regenerate a severed spinal cord and lift someone from a wheelchair. t o spur insulin production and spare a child from a lifetime of needles. To treat Parkinson's, cancer, heart disease and others that affect millions of a mericans and the people who love them.

o bama also argued the *economic competitiveness* frame that has been frequently applied by funding proponents, asserting the US risked losing scientists to other countries if research did not move forward.

Yet perhaps most importantly, Obama was explicit in acknowledging that science alone did not drive policy choices and decisions. t he President, in fact, was careful to articulate the second premise that lay behind his decision. First, he defined his decision in terms of a *moral and ethical* duty to help those in need. Second, he cited his *public accountability* duty to be in line with the wishes of a majority of Americans. Notice specifically how Obama referenced his religious beliefs as compelling action:

> As a person of faith, I believe we are called to care for each other and work to ease human suffering. i believe we have been given the capacity and will to pursue this research – and the humanity and conscience to do so responsibly. The majority of Americans – from across the political spectrum, and of all backgrounds and beliefs – have come to a consensus that we should pursue this research. t hat the potential it offers is great, and with proper guidelines and strict oversight, the perils can be avoided. t hat is a conclusion with which i agree. t hat is why i am signing this e xecutive o rder, and why i hope Congress will act on a bi-partisan basis to provide further support for this research.

in stating the religious reasoning behind his decision, o bama is no different than former President George W. Bush, who was equally open about the values that guided his decision to *limit* embryonic stem cell funding. a s a direct parallel to o bama's religious reasoning, consider this statement from Bush's a ugust 2001 speech announcing his compromise funding for stem cell research:

> my position on these issues is shaped by deeply held beliefs. i'm a strong supporter of science and technology, and believe they have the potential for incredible good -- to improve lives, to save life, to conquer disease. I also believe human life is a sacred gift from our creator. i worry about a culture that devalues life, and believe as your president i have an important obligation to foster and encourage respect for life in a merica and throughout the world.

o r consider this September, 2006 Bush speech announcing his decision to veto a Congressional bill that would have expanded funding for embryonic stem cell research. t he speech was delivered at a press conference where Bush was surrounded by 'snowflake babies,' children born from adopted embryos that otherwise would have been discarded by their biological parents and the respective fertilization clinic:

> This bill would support the taking of innocent human life. Each of these human embryos is a unique human life with inherent dignity and matchless value. These boys and girls are not spare parts.

A recognition of the need to frame both the first and second premise also comes through in Obama's statement on scientific integrity, delivered as part of his stem cell announcement. in short, o bama's directive to his science advisors to 'develop a strategy for restoring scientific integrity to government decision-making' is about protecting the ability of scientists to establish the first premise, to be free to accurately identify through research various potential opportunities and risks to society.

This, in fact, is the significant difference between the Bush and Obama administrations, at least at this early part of the latter president's term. When it comes to the second premise, both openly apply their own set of values in deciding how to take policy action on the conclusions of science. As a matter of governing there is no way to avoid applying values to craft science policy. Scientists, journalists, and elected officials need to transparently articulate this reality. Where o bama and Bush appear to differ is that the Bush administration was also willing to move into the territory of the first premise. On issues such as climate change, as a number of investigations have revealed, the Bush administration actually shaped, re-framed, or even obstructed what scientists had concluded about climate change-related risks.

in sum, when science policy debates are simplistically reduced down to a 'debate over the science' or a matter of 'inconvenient truths,' with discussion of values and politics lost in the translation, framing is most likely to be applied unethically, violating the norm of accuracy, and used to hype, exaggerate, or distort scientific evidence. Indeed, if scientists, journalists, and a range of political actors were more open and transparent about the values guiding their preferred policy actions both public engagement and dialogue would be likely to benefit.

in spring 2007, *The Scientist* magazine sponsored an online discussion of framing and its implications for science communication. in one posting, environmental advocate Mark Powell succinctly summarized this key distinction between communicating the first and second premise:

> I left active science to work as an environmental advocate. I learned quickly that values trump hard facts – for instance, people in a logging town had a hard time believing that logging could cause harm, because their value structure was threatened by such a claim. if i started my communications with 'logging can harm forest eco-systems,' i mostly got denial and dismissal. instead, if i started with 'do you care about deer and salmon?' then people would say yes and engage in conversation. l ater, i could get to my science about logging effects on salmon. is it lying? n o, it's framing and it's smart (*The Scientist*, 2007, p. 42).

t ruth-telling, issue advocates, and honest brokers

As professionals, both scientists and journalists share a deep ethical commitment to truth-telling and accuracy. For example, scientists have developed a shared set of rules for translating research questions into their testable forms, collecting and evaluating data, and communicating the results. t hese rules are used to ensure inter-subjectivity and the replication of observations and conclusions, allowing scientists to figure out what is approximately true about the world and to do so while minimizing social biases and value-laden observations. a cross many policy debates there usually exists expert agreement – or at least an emerging body of scientific knowledge – by which first premise truth claims can be evaluated.

Similarly in journalism, methods have been developed for achieving accuracy. These methods include fact-checking and the reliance on multiple and credible sources. in the u nited States historically, the deep professional emphasis on accuracy derives from a belief that focusing on 'who, what, where, when, and how' is the best means for capturing a broad-based audience while avoiding political and legal conflicts (Christians, 2008; Danielian, 2008).

Though there is little question that scientists have developed an unrivaled institutional ability to arrive at approximately true observations about the world, as political scientist Roger Pielke (2007) argues, there are really only two communication roles that scientists can play in policy-related debates and the reality of these roles might in fact be at odds with how scientists prefer to define themselves. As he describes, many scientists prefer to think of themselves as creating knowledge that can be drawn upon by policymakers but not entering into policy debates themselves. Though this self-defined role has great appeal, in reality even so-called pure scientists often engage in strategic communication as a means to promote their careers or to ensure continued government funding, framing research heavily in terms of *social progress*, societal benefits, breakthroughs and *economic competitiveness* (Hellsten and Nerlich, 2008).

a second imagined policy role among scientists is as a neutral ‘science arbiter,’ providing science-related information, expertise, testimony, and reports when called upon by policymakers. However, as Pielke (2007) details with the example of the food pyramid and u S dietary guidelines, advisory committees and expert panels often engage in implicit normative considerations when providing scientific advice or provide input on a narrow set of predetermined policy options (see also Hilgartner, 2000). A result is that the imagined role of science arbiter shifts into stealth issue advocacy.

Still, according to Pielke (2007), issue advocate is one of the authentic communication roles that scientists do assume in policy debates. indeed, there is nothing ethically wrong with scientists serving as issue advocates, as long as they follow the normative imperatives outlined so far, namely that they are open and transparent about their advocacy, communicate the values that shape their policy preferences, and are true to what is conventionally known about the related science.[3] a fter all, scientists are citizens too and have their own self-interests and values at stake in many policy debates. On evolution, for example, leading science organizations advocate in a bi-partisan way for a clear policy outcome: teaching only evolution in public school science classes. Similarly, on embryonic stem cell research, most scientists favor unrestricted government funding for research (stopping short, of course, of human cloning).

While scientists are often – and justifiably – issue advocates, they can also serve as what Pielke calls honest brokers. In this role, a diversity of scientists, operating for example as an interdisciplinary National Academies panel, seeks to ‘place scientific understandings in the context of a smorgasbord of policy options’ (p. 17). When scientists communicate from the position of honest broker, they openly acknowledge that science alone will not resolve political differences over policy.

instead scientists use their expertise to expand the scope and diversity of policy options under consideration. For example, on climate change, scientists serving as honest brokers would provide input on the feasibility of cap and trade legislation to reduce greenhouse gas emissions, but they would also highlight alternative actions such as the potential of alternative energy technology to reduce emissions or the ability of technology to capture and remove carbon dioxide from the atmosphere (see Tierney, 2009 for a recent discussion).

Pielke’s categories of issue advocate and honest broker can also be applied to the communication role of journalists in science policy debates, especially in an era when journalists seek new financial models for news production and delivery. For example, many veteran science journalists have been forced to leave their jobs at major news organizations while early career journalists encounter limited job prospects. As an alternative career path, some science reporters have joined with

3 in the next section, i discuss two other important imperatives, namely to avoid denigrating or stereotyping rival social groups and to avoid defining one political party or political candidate as either ‘pro-science’ or ‘anti-science.’

universities or foundations to work at the type of emerging participatory digital media outlets described earlier. t he goal at these outlets is not only to inform but also to engage and mobilize the public around problems such as climate change.

Yet whether a journalist is playing the role of issue advocate or honest broker, the same ethical imperative of accuracy and truth-telling applies. Journalists should not engage in the false balancing of first premise claims on issues such as climate change where there is clear expert agreement in the area. n or should they exaggerate the implications of expert consensus as a way to dramatize a complex topic such as climate change. Otherwise, journalists risk their own credibility and do further harm to public trust in the media as a conveyer of reliable information about science and public affairs (see Revkin, 2007; 2009 for discussions).

Communication as consensus or con.ict?

in January 2008, the n ational a cademies issued a revised edition of *Science, Evolution, and Creationism*, a report intentionally framed in a manner that would more effectively engage audiences who remain uncertain about evolution and its place in the public school curriculum. t o guide their efforts, the a cademies commissioned focus groups and a national survey to gauge the extent of lay citizens' understanding of the processes, nature, and limits of science. They also specifically wanted to test various frames that explained why alternatives to evolution were inappropriate for science class (Labov and Pope, 2008). The National Academies' use of audience research in structuring their report is worth reviewing, since it stands as a leading example of how to ethically employ framing to move beyond polarization and to promote public dialogue on historically divisive issues.

t he a cademies' committee had expected that a convincing storyline for the public on evolution would be a *public accountability* frame, emphasizing past legal decisions and the doctrine of church-state separation. Yet the data revealed that audiences were not persuaded by this framing of the issue. instead, somewhat surprisingly, the research pointed to the effectiveness of a *social progress* frame that defined evolutionary science as the modern building block for advances in medicine and agriculture. t he research also underscored the effectiveness of a *middle-way compromise* frame, emphasizing for the public the n ational a cademies' longstanding position that evolution and religious faith can be fully compatible. Taking careful note of this feedback, the National Academies decided to structure and then publicize the final version of the report around these core frames.

t o reinforce these messages, the n ational a cademies report was produced in partnership with the institute of m edicine and the authoring committee chaired by Francisco a yala, a leading biologist who had once trained for the Catholic priesthood. t he report opens with a compelling 'detective story' narrative of the supporting evidence for evolution, yet placed prominently in the first few pages is a call out box titled 'e volution in m edicine: Combating n ew infectious Diseases,' featuring an iconic picture of passengers on a plane wearing SARS masks. On subsequent pages, other social progress examples are made prominent in call out boxes titled 'e volution in a griculture: t he Domestication of Wheat' and 'Evolving Industry: Putting Natural Selection to Work.' Lead quotes in the press release feature a similar emphasis.

To engage religious audiences, at the end of the first chapter, following a definition of science, there is a prominent three page special colour section that features testimonials from religious scientists, religious leaders and official church position statements, all endorsing the view that religion and evolution are compatible. Both the report and the press release state that: 't he evidence for evolution can be fully compatible with religious faith. Science and religion are different ways of understanding the world. n eedlessly placing them in opposition reduces the potential of each to contribute to a better future.' In a subsequent journal editorial, these core themes as featured in the report were endorsed by twenty professional science societies and organizations (FASEB 2008).

The Richard Dawkins School of Communication

For the National Academies and these professional societies, political conflicts over evolution have yielded a lesson learned as to the importance of connecting with diverse audiences and building consensus around commonly shared values. Yet what continues to be the loudest science-affiliated voice on the matter of evolution takes a decidedly different framing strategy. Several scientist authors and pundits, led by the biologist Richard Dawkins (2006), argue that the implications of evolutionary science undermine not only the validity of religion but also respect for all religious faith. t heir claims help fuel the *conflict* frame in the news media, generating journalistic frame devices that emphasize 'God vs. Science,' or 'Science versus religion.' These maverick communicators, dubbed 'The New Atheists,' also reinforce deficit model thinking, consistently blaming conflict over evolution on public ignorance and irrational religious beliefs.

Dawkins, for example, argues as a scientist that religion is comparable to a mental virus or 'meme' that can be explained through evolution, that religious believers are delusional, and that in contrast, atheists are representative of a healthy, independent, and pro-science mind. In making these claims, not only does Dawkins use his authority as the former 'Oxford University Professor of the Public u nderstanding of Science' to denigrate various social groups, but he gives resonance to the false narrative of social conservatives that the scientific establishment has an anti-religion agenda.

The conflict narrative is powerfully employed in the 2008 anti-evolution documentary *Expelled: No Intelligence Allowed*. By relying almost exclusively on interviews with outspoken atheist scientists such as Dawkins and the blogger PZ m yers, *Expelled* reinforces the false impression that evolution and faith are inherently incompatible and that scientists are openly hostile to religion. in the film, the comedic actor Ben Stein plays the role of a conservative Michael Moore, taking viewers on an investigative journey into the realm of 'Big Science,' an institution where Stein concludes that 'scientists are not allowed to even think thoughts that involve an intelligent creator.'

Stein and the film's producers employ a *public accountability* narrative to suggest that scientists have been denied tenure and that research has been suppressed, all in the service of an atheist agenda to hide the supposedly fatal flaws in evolutionary theory. As central frame devices, the film uses historic footage of the Berlin Wall and emphasizes freedom as a central a merican value. t he sinister message is that 'Darwinism' has led to atheism, fascism, and communism. a s a corollary, if Americans can join Stein in tearing down the wall of censorship in science it would open the way to religious freedom and cultural renewal.

One leading example from the film is an interview with Myers, a professor of biology at the u niversity of m innesota-m orris, and author of the Pharyngula blog. Myers' comments in the film reflect much of the content of his blog, which is estimated to receive over a 1 million readers per month. interviewed in his laboratory, against a backdrop of microscopes and scientific equipment, Myers offers the following view of religion:

> Religion is naivete that gives some people comfort and we don't want to take it away from them. It's like knitting, people like to knit. We are not going to take their knitting needles away, we are not going to take away their churches, but we have to get it to a place where religion is treated at a level that it should be treated. That is something fun that people get together and do on the weekend, and really doesn't affect their life as much as it has been so far.

in a follow up, when prompted to discuss how he believes this goal might be accomplished, Myers offers a line of reasoning that reflects the deficit model paradigm, arguing that science literacy is in direct conflict with religious belief:

> g reater science literacy, which is going to lead to the erosion of religion, and then we will get this nice positive feedback mechanism going where as religion slowly fades away we will get more and more science to replace it, and that will displace more and more religion which will allow more and more science in and we will eventually get to that point where religion has taken that appropriate place as a side dish rather than a main course.

By the end of its spring 2008 run in theaters, *Expelled* ranked as one of the top grossing public affairs documentaries in u .S. history. e ven more troubling have been the advanced screenings of *Expelled* for policymakers, interest groups, and other influentials. These screenings have been used to promote 'Academic Freedom a cts' in several states, legislation that would encourage teachers (as a matter of 'academic freedom') to discuss the alleged flaws in evolutionary science. In June 2008, a version of these bills was successfully passed into law in l ouisiana with similar legislation under consideration in other states (see n isbet, 2008; 2009a for more).

As social critics and pundits, there is nothing ethically wrong with Dawkins, m yers, and other so-called n ew a theists arguing their personal views on religion, using as exclamation points carefully framed comparisons to fairies, hobgoblins, knitting, and child abuse. Similar to the feminist movement of the 1960s, Dawkins describes his communication goal as ‘consciousness raising’ among the non-religious and those skeptical of religion.

Yet when Dawkins and other New Atheists also use the trust granted them as scientists to argue that religion is a scientific question, that science undermines even respect for religious publics, they employ framing unethically, drawing upon the rhetorical authority of science to stigmatize and attack various social groups. in the process, n ew a theists turn what normatively should be a public dialogue about science and religion into a shouting match and media spectacle.

Partisan soldiers with science on their side

As described earlier, a significant difference between the Bush and Obama administrations, at least at this early stage in the latter’s presidency, is that the Bush administration appeared willing to distort, obstruct, and re-frame for political gain the ‘first premise’ conclusions of scientific experts and agencies, especially on scientific research related to climate change and the environment.

In response, during the Bush administration, many scientists, journalists, elected officials, and political strategists focused on *public accountability* as a call-to-arms ‘to defend science.’ t hese advocates accused the g eorge W. Bush administration of putting politics ahead of science and expertise on a number of issues, including climate change. For example, in the 2004 election, Democratic presidential candidate U.S. Senator John Kerry (D-MA) made strategic use of the *public accountability* frame, comparing distortions on climate change to the administration’s use of intelligence to invade Iraq: ‘‘What I worry about with the president is that he’s not acknowledging what’s on the ground, he’s not acknowledging the realities of North Korea, he’s not acknowledging the truth of the science of stem-cell research or of global warming and other issues.’

In 2005, journalist Chris Mooney’s best-selling *The Republican War on Science* helped crystallize the *public accountability* train of thought, turning the ‘war on science’ into a partisan rallying cry. In 2007, Hillary Clinton, in a speech marking the 50th anniversary of Sputnik, promised to end the ‘war on science’ in American politics, highlighting the emergent prominence of this frame device.

t he *public accountability* frame has outraged and intensified the commitment of many Democrats, environmental advocates, and scientists, motivating them to label Republican and conservative political figures as ‘deniers’ on climate change and to engage in sharp rhetorical attacks on political opponents in other policy disputes. Yet for many members of the public, ‘war on science’ claims are likely ignored as just more elite rancor or only further alienate Republicans on the issue.

Framing will always be a part of electoral politics and scientists as citizens should actively participate in political campaigns. Yet similar to the case of n ew

Atheists, if scientists speak from their authority and institutional position as trusted experts, using framing to claim that a specific political party or a candidate is either 'pro-science' or 'anti-science,' the result is likely to be both normatively and strategically undesirable.

First, claims of a 'war on science' or a 'rising anti-science culture' are inaccurate – and similar to the New Atheist movement – reinforce deficit model assumptions. In Congress, for example, on the great majority of issues there is widespread bi-partisan support for science, a reality reflected in Federal spending on basic research and bi-partisan boosterism in areas such as food biotechnology (see Nisbet and Huge, 2006 for a review). Even members of Congress who personally believe in creationism are likely to vote for broad-based funding of scientific research, since they perceive science generally in terms of *social progress* and *economic competitiveness*. m oreover, in terms of the general public, as detailed at the beginning of this chapter, public opinion research shows that science and scientists enjoy widespread admiration, trust, and support among Americans, no matter their political identification or religious views.

The unintended consequence of 'war on science' claims is that given the miserly nature of the public, the framing strategy easily reinforces the partisan divide on issues such as stem cell research and climate change while promoting a false narrative that science is for Democrats and not for r epublicans. Since 2004, when the Democratic Party began to use stem cell research and climate change as part of an electoral 'wedge strategy,' public perceptions have predictably followed. With these partisan messages as a strong heuristic, polls show that the differences between Democrats and r epublicans in their views of embryonic stem cell research and climate change have widened to more than thirty percentage points respectively (Dunlap and m cCright 2008; Pew 2008; VCu l ife Sciences, 2008).

in fact, this persistent and widening gap in perceptions over the past decade suggests that climate change and stem cell research have joined a short list of issues such as gun control or taxes that define what it means to be a partisan in the United States. So like the New Atheists, while 'war on science' claimants believe they are defending the integrity of science, they are more likely to be part of the communication problem, reinforcing partisan divisions across key issues.

Conclusion

in this chapter, i have argued that in communicating about science-related policy issues, scientists and journalists can adopt one of two roles, either serving as honest brokers or as issue advocates. In either role, the use of framing is unavoidable since it is a natural part of the communication process. in fact, past research points to a set of frames that apply consistently across science-related debates, serving as interpretative resources that society draws upon to collectively make sense of complex and uncertain policy choices.

Even though it is very difficult to ‘break the frame’ on a science-related topic, this deductive typology for identifying the meanings and interpretations surrounding a policy-debate can be very useful. a udience-based research can and should inform communication planning and strategy, leading to a range of potential outcomes. Yet in applying framing research to public engagement efforts, there are four key ethical imperatives to keep in mind. These include:

- e mphasizing dialogue and the exchange of perspectives, rather than traditional top-down approaches to communication. t his imperative can be promoted either through face-to-face deliberative forums, new models of digital participatory media, and/or as in the case of the n ational a cademies, using research to identify frames that emphasize common ground and promote dialogue.
- e ffectively and transparently communicating the values – or the second premise – that guides a policy decision rather than simplistically defining a policy debate as a matter of ‘sound science’ or ‘driven by science.’ in a policy debate, when scientists or journalists focus exclusively on these types of first premise claims, they create the incentives for interest groups to turn science into just another political resource, leading to distortion and exaggerations over scientific evidence and uncertainty.
- No matter their role as issue advocate or honest broker, accuracy in communication needs to be maintained. Both scientists and journalists must respect the uncertainty that is inherent to any technical question, resisting the tendency to engage in either false balance or exaggeration. a s in the case of climate change, each time a scientific claim is proven false or inaccurate, it risks further alienating publics already distrustful of the science and scientists.
- Finally, scientists and journalists should avoid using framing to denigrate or attack religion or to define political parties and leaders as either ‘anti-science’ or ‘pro-science.’ Framing will always be an effective and legitimate part of social criticism and electoral politics, but for scientists and journalists to simplistically define critiques of religion or opposition to a political candidate as a ‘matter of science and reason’ is not only inaccurate, but also alienates key publics, impairing efforts at dialogue and consensus-building.

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Chapter 5
Bioethical Decisions and the Public Sphere: a Cross-Cultural Perspective

Christoph r ehmann-Sutter

in his account of the ‘ethos of science’ of 1942, sociologist r obert K. m erton quoted an illustrative sentence from Louis Pasteur: ‘*Le savant a une patrie, la science n’en a pas*’ (Merton 1968: 608). Pasteur’s statement, in Merton’s text, was evidence of the norm of ‘universalism’, which was the first of four constitutive features of his account of the normative framework that makes a search for knowledge ‘scientific’. Mertonian scientific knowledge should be unbiased and ‘objective’. Its norm should not be bound by a particular tradition or culture (or nation), or by the idiosyncratic taste and preference of an individual. There might be ‘styles’ in science, culturally inspired frames, terminology, metaphors and images, research priorities and problem definitions. Certainly there are national funding patterns, but there is no English, Chinese or French scientific ‘truth’, no Eastern or Western methodology in science. t his has been largely uncontested. t here might be other forms of knowledge beyond science. I do not use the derogatory word ‘pseudoscience’ here (Lakatos 1977), because I am thinking of such indispensable things as moral wisdom, life experience, body knowledge etc., for which culture is indeed constitutive. But for scientific knowledge, cultural interpretations can only be irrelevant.

Accordingly, the discourses in the ‘scientific community’ are essentially international and cross-cultural, represented in internationally accessible scientific journals, most of them written in English as the *lingua franca* of science. We could even say that, in the 20th century, a distinct ‘scientific culture’ emerged, defined by its international and cross-cultural nature that embodies scientific forms of openness and criticism characteristic of scientific research collaborations and technology development. Science, according to its enthusiasts, has the potential to build an overarching, rational and essentially common understanding of the world, for the benefit of all global citizens, unhampered by culturally-specific metaphysics and religion.

But, as we know, science is not just about knowledge. The life sciences are also a technology – and practice-related endeavour. Biological research is intricately bound to new technological developments like genetic engineering or genome sequencing. Medicine improved tremendously in the 20th century and there is a great desire for further progress. The ‘therapeutic promise’ (Rubin 2008) is omnipresent, surprisingly flexible and immune to disappointments, and influences strategic decision-making in bio-politics. Science is not just cognitive, but also practical: involving experimentation, tinkering, planning, cooperation with other groups internationally, and the setting up of research agendas that can be more or less responsive to the most urgent problems of individual societies.

Beginning in the 1960s, a new awareness of the ethical implications of research and technology development in the life sciences grew, which led to the development of 'bioethics' as a specialized discourse (Jonsen 1998). It focused on questions about the moral limits of genetic engineering, the acceptable use of technology in medicine, and also on questions about the ecological and social implications of research. l arge research programmes, most notably the strongly international Human Genome Project, have been accompanied by initiatives to foster reflective interdisciplinary research into their ethical, legal and social aspects or implications ('ELSA', see Glasner and Rothman 1998, Clayton 2003). And increasingly, awareness has grown that ecological risks and industrial accidents on an ever larger scale are normal and endemic in the cause of scientific-technological progress. r eviewing these disturbing phenomena, of which Bhopal, Chernobyl and g lobal Warming are but prominent examples, Sheila Jasanoff (this volume) calls for a new approach to technology, based on humility instead of hubris. It should acknowledge the limits of prediction and control, and get to grips with the unknown, the ambiguous, and the uncontrollable. Above all, technologies of humility are reflective and participatory, characterized by a self-understanding of science and technology as social and political action.

Knowledge about the ethical, legal and social aspects of science and technology, however, cannot meet the norm of universalism, at least not in the same way as scientific knowledge itself. Ethical issues in genomics, biotechnology or medicine, and also the methodologies for investigating and resolving them, are evidently and necessarily bound to ways of life within their concrete history. t hey arise locally and contextually, within the particular structures of a society. t he destruction of early human embryos in stem cell research, to pick just one example, is considered an insurmountable problem in the moral and legal traditions of g ermany, a ustria and italy, while being a moral and legal non-issue in China. t he discussion of moral issues is inseparable from meaningful interpretations originating in rich, cultural contexts, that provide frames and narratives. But some of the eco-social issues (the loss of biodiversity, the greenhouse effect etc.) are indeed international, and they systematically cross cultural divides.

t here is a problem here. h ow can el Sa research and communication about ethics meet the diverse requirements of local and cultural circumstances, and at the same time adequately tackle international and cross-cultural dimensions? Which approach to the ethical component of el Sa is suitable for multicultural deliberations? Such an approach should pave a way between the *Scylla* of abstract moral universalism and the *Charybdis* of moral relativism. The first is too theoretical and lacks a basis in the perceptions and concerns of real people, while the second gets stuck in the particular and prevents rather than facilitates cross-cultural understanding.

t his chapter adopts a politico-ethical perspective, and argues that a third way between universalism and relativism is possible and indeed recommendable for the international space. t he central idea that i will explore and advocate is the 'public sphere'. It corresponds to a modest meta-ethical position that acknowledges the essential cultural nature of ethical discourse, but does not reject the possibility (and necessity) of cross-cultural understanding. Drawing on literature from critical theory, i shall explain and discuss the concept of a trans-cultural international public sphere as a normative idea. m y instinct is that cross-cultural el Sa could be both an opportunity for and a real step towards creating a trans-cultural and international public sphere. 'Public' decision-making must essentially be a joint enterprise, i.e. a social practice. This means that we cannot understand public decision-making as an extrapolation of individual decision-making, which we perhaps think we know better from our own day-to-day experience as individual perceivers and actors, and from the strong individualist traditions of modern Western ethics. i start with this question: what, in a multicultural and increasingly also post-national constellation, makes a public 'public'? And what kind of 'publicity' is necessary or helpful when tackling the ethical, social and political implications of the biological sciences?

Decision-making and the public sphere

t he *public sphere* can be a central concept in cross-cultural engagement in ethical, legal and social issues in and around the life sciences. Unlike the atmosphere or the biosphere, the public sphere is not an empirical term. it is a normative idea. But *like* the atmosphere and biosphere, the idea of the public sphere is a spatial image: a space not somewhere else but a space that surrounds us, encompasses us and connects us with others. t he public sphere, in contrast to other 'spheres', is not a natural element. it has its structural roots in various public 'arenas' and also depends on our personal engagement with them and on *how* we engage with and connect ourselves to others. t his means that the public sphere is a genuinely social and political space. it has a political and cultural history and a structure that depends on how people communicated in the past, and on how those with political power organized the relevant parts of social interaction so as to constrain how people communicate and what they communicate about in the present and, possibly, in the future. It is also a fluid and complex space for communications, which is composed of multiple publics, including, what Nancy Fraser (1992: 116) has called 'competing counterpublics'.

Contemporary discussion of the public sphere has been inspired by Jürgen h abermas' historical study of the 'structural transformation of the public sphere' in Europe (Habermas 1962), which investigated the changes from a feudal model of the state that lacked a public sphere to, in the 18th century, a 'bourgeois' liberal model, through which a new kind of journal or newspaper emerged that not only reported news but publicized opinions and assessments that were then open for discussion. t he social welfare state in developed industrial societies, with its mass democracies, changed once again the structural constellation of the public sphere, introducing new mass media and new challenges such as conflations of information with entertainment and the selection of issues that are reported. t his history makes the public sphere of great relevance to technology discussions and discussions of the media.

For Habermas, the first defining element of the public sphere is the social space that is generated by an open exchange of opinions about matters of common concern. Flows of communication are 'filtered and synthesized' to form topically-focused public opinions (Habermas 1992: 435–437) But what is a public opinion?

According to Habermas, a public opinion is not just an opinion that is publicly shared or publicized. it is not what is in fact public, in the sense that it is made public by some sort of public media. it is essentially an opinion that is developed in the realm of a 'reasoning public'. h abermas explains this by contrasting it with cultural attitudes and the traditional opinions of some groups within society. 't hough mere opinions (cultural assumptions, normative attitudes, collective prejudices and values) seem to persist unchanged in their natural form as a kind of sediment of history, public opinion can by definition come into existence only when a reasoning public is presupposed' (2006: 74). Clearly this is relevant to the public discussion of bioethical issues, particularly across different cultural traditions. In bioethical matters, public statements by stakeholders contain many cultural assumptions (e.g. assumptions about what counts as 'progress'), normative attitudes (e.g. about justice in health care), collective prejudices (e.g. expectations regarding the role of genes in human life) and collective values (e.g. regarding the moral dignity of human embryos). Public opinion can come into existence if, and only if, these assumptions, attitudes, judgments and values are aired and challenged in an open and reflective public discussion (what in German is called *öffentlichkeit* – a word that has direct semantic roots in 'openness'), where they are scrutinized against the alternatives by asking why they might be valid, or why they are worth adopting. a public opinion is essentially an assembly of critical views. t herefore, the public sphere can function as a 'warning system with non-specialised sensors' (Habermas 1992: 435).

Thus it contributes to political legitimacy, which is the first of two essential features that characterize the concept of the public sphere. t he second one (Fraser 2007: 7) is political efficacy. In order to have impact, the concept of a public sphere needs an element of power: the power of decision-making in practical matters. in the modern state, the political public sphere wins an institutionalized influence over the government through the instrument of law-making bodies. State authority, insists Habermas (2006), is not part of the public sphere. Rather, the communications, which make up the public sphere, address the sovereign power, and it depends on the structure of the political institutions whether and how well they can respond. Fraser (2007: 7) explains this relation of the public sphere to political authority as follows. it 'is supposed to discredit views that cannot withstand critical scrutiny and to assure the legitimacy of those that do. […] in addition, a public sphere is conceived as a vehicle for marshalling public opinion as a political force'.

While maintaining the original intention of the concept, Fraser has criticized h abermas' formulation as too narrow and also too idealistic (Fraser 1992, see also Benhabib 2002: 142–145). The political, as she sees it in a post-national constellation, is no longer restricted to the sovereign territorial nation-state. in order to include other, non-state powers on a larger or smaller scale – whether international (regional trading blocks like the European Union or NAFTA, bodies like the World Bank, the IMF or the World Medical Association), sub-national (municipal and provincial agencies, universities, corporations and associations of all kinds) or transnational cooperations (e.g. in ethical governance of research) – the concept of the public sphere must be broadened, and the political influence of public opinion must not be restricted to national parliaments. t his conceptual move represents, as Fraser (2007: 15) puts it, 'another structural transformation of the public sphere' and is important for cross-cultural el Sa .

What is won by emphasizing the role of the public sphere in bio-political decision-making? I see two essential advantages for public decision-making over exclusive, more authoritarian, or expert-bound styles of decision-making. The first is cognitive: a public decision can consider many more perspectives, experiences and views, some of them unexpected and unavailable in the sphere of established expert knowledge. In genetic medicine for instance, the lay knowledge of patients and their families can provide important information about a disease and its implications, about their relationship with medical professionals, etc. t herefore a public decision will be based on an enlarged knowledge resource. The second advantage is the moral recognition of those affected. t o be included in, rather than excluded from, the decision-making process, makes a huge difference to those who have to accept the implications of a decision. i hesitate in using the loaded term 'autonomy' here, but to have the chance to be included in the decision-making process suggests a degree of respect for the autonomy of those who will be affected by the decision. e ven if an individual does not actually participate in the decision-making process, having the opportunity to participate is a recognition of their moral capacity to do so and their relationship to the outcomes of the process will differ as a result, perhaps becoming more affirmative. Whatever it may mean in concrete terms, the decision has, at least to some extent, been made democratically.

In ELSA topics, decisions frequently have implications for lifestyle, health and environmental risks. The acceptability of those implications, in the views of those affected depends, among other things, on having the chance to participate in decision-making (Rehmann-Sutter and Vatter 1996). To be included in the process of decision-making via participation in the public sphere is not the same as informed consent in clinical medicine, where the concept of autonomy has been used extensively, but both concepts share the ideas of recognition and respect.

Practical challenges in public decision-making

When the idea of public decision-making is put into practice in multicultural settings, a range of problems arise that are important to address. o ne of the most basic problems is that of inclusion and exclusion. l et me give an illustration. Today's version of the article on the 'public sphere' on the Wikipedia website (3 January 2009) shows, as the first of five images, an old black and white photograph of twelve, mostly white-bearded men in turbans sitting on a carpet, out in the open, drinking coffee from small cups and grinding more coffee beans in a dark stone mortar. The picture is taken from a stereoscope card in the Keystone collection. a ccording to the caption it is a coffeehouse in Palestine in 1900. Some of the men are talking. Others are quietly holding their cups. The atmosphere seems to be relaxed and quiet. This picture is meant to be a symbol of equality and mutual recognition. But of course it can also be read as a symbol of the logic of inclusion and exclusion. Where are the women, the younger people, those who don't have time free from labour, those with different faiths, those who cannot walk? How would this atmosphere of demonstrative equality be changed if those whose inequality is obvious were present? There are obviously rules that govern this one public sphere, of which variants can be found everywhere: rules that define who can take part, with whom it is easy and attractive to communicate, and how those who take part should behave.

Fraser (1992) criticizes the 'bourgeois' conception of the public sphere, which is perhaps similar to this picture of the free, honourable men in the coffeehouse. She argues that it is not in fact possible for interlocutors to bracket status differentials and deliberate as if they were social equals, when they are not. Societal equality, she concludes, is a necessary condition for political democracy. h owever, in the current post-national constellations, with phenomena such as migrations, diasporas, dual citizenship, indigenous community membership, multiple residency and multiculturality, Fraser recognizes that 'often the interlocutors are neither co-nationals nor fellow citizens' (Fraser 2007: 16). Under these circumstances, new patterns of inclusion and exclusion have emerged, which cannot be addressed by the classical approaches of formal equality for everybody through citizen's rights. Challenges to inclusiveness and participatory parity (Fraser 2007: 20) also apply to el Sa and to the corresponding cross-cultural public spheres to which ELSA contributes. Political equality and the public sphere therefore need to be re-thought.

Cross-cultural communication, in the present constellations of post-nationality and multiculturality, has both a national and a transnational dimension. m ulticulturality is no longer an international phenomenon, since it is increasingly bound by the borders of states. This has two advantages: firstly, we do not need to look far to find situations where inclusion is problematic; and secondly we can hope that improving international cross-cultural understanding will also have a positive effect on *intra*-national cross-cultural understanding.

In a multicultural setting, equal and open access to the public sphere in ethical, legal and social aspects of the life sciences is challenged in many ways. Some of them are obvious but should be noted anyway.

1. In order to understand many ELSA topics (like personalized genomics or genetic engineering), which involve scientific, medical *and* social aspects, a broad higher education is needed, to provide a minimum level of 'literacy' in the language of the sciences, the humanities and medicine. h owever, inter- and intra-national distribution of education across cultural communities remains unequal.
2. Access to relevant information is not straightforward. The media are a key means of distributing important knowledge to a broad audience, and they should not be criticized for doing this in a necessarily simplified format. However, simplification also creates a division between those who can look beyond the popular version and those who cannot. Simplified information packets provided by the media are not, therefore, always free from selection and interpretative bias.
3. Access to the media is itself limited and unequally distributed. In many parts of the world, computers with internet connections are rare and international newspapers are unavailable or unaffordable for many, never mind books, scientific journals or libraries.
4. t he media themselves are not always interested in providing information on all the relevant topics at an appropriate time for decision-making, because they select 'stories' according to their attractiveness to local markets and to the advertisers who provide the main part of their income (Michelle 2006). t here is, therefore, some degree of self-interest on the part of t V channels or newspapers, which influences their selection of information and the way it is presented. This self-interest can conflict with the public's best interests.
5. t he time and resources that an individual can devote to each el Sa topic are naturally limited. m odern technological societies are highly complex, and there are many more publicly-relevant decisions needing to be taken within a given timeframe than could possibly be achieved through an extended public decision-making process. Therefore, only a small fraction of the relevant themes can be broadly and openly discussed. Public decision-making is necessarily selective; otherwise social life and economic development would come to a halt.[1]
6. t he style and terminology that predominate in ethical discussions can be exclusive and (like Western 'bioethics') obviously depend on a particular discursive culture rooted in the occidental (mainly g reco-

1 in my home country, Switzerland, which is a direct participatory democracy, public national referenda are held four times per year, on fixed dates, each time with a relatively low number (ca. 2–6) of decisions. In addition there are also periodic parliamentary elections and votes at cantonal or community level.

Roman) philosophical tradition. Not all groups have the communicative power or interest to propose a change of style or develop new frames and terminologies rooted in more exotic cultural traditions.

7. Many international participatory exercises and organized discourses (like conferences, symposia and workshops), even if they are publicly accessible at low cost, are formal, and can only involve a small selected number of people who are used to appearing on such platforms.
8. o ne of the exclusive factors for cross-cultural understanding can be culture itself. Culture, as i use the term here (for discussions see e agleton 2000 and Inglis 1993), means a sphere of socialized and accumulated practical habits, narratives and values among a large group of people who share something like a collective memory bank and sometimes also a dominant language or religion. t hese narratives and values might be fractured, in-homogenous, contested and contestable for participants (Benhabib 2002: 5), but they are used to frame old and new topics and issues in daily life. t hey are, as Ngugi wa Thiong'o (Ashcroft et al. 1995) has expressed it, 'the set of spiritual eyeglasses' through which participants come 'to view themselves and their place in the universe'. Cultures are stabilizers in a fluid world, but they are themselves 'constructed, flexible and subject to renewal' (Jasanoff 2005: 22). If a communicative setting is dominated by participants from one culture, the participation of other participants can be difficult.

Taking these points into consideration, we see that the construction of a cross-cultural public sphere on ELSA topics demands skilful science communication and careful attention on a case-by-case basis. interest and understanding among the concerned public does not always arise naturally. t he groups with a high level of interest in participating may or may not coincide with those who are affected by an issue. *How* to achieve involvement in as-fair-as-possible public spheres should itself be a topic for el Sa research. e mpirical research about public arenas, and also about failures in constructing a public sphere in some instances can form a basis for developing new methods and improving inclusion-exclusion effects.

Public versus individual decision-making

The concept of decision-making in the public sphere has the advantage that it does not treat public decisions as enlarged versions of individual decisions. individuals take part in social processes that lead to public decisions, but the decision-making body is not a super-organism built on the model of an individual self. When considering issues of public decision-making about the societal implications of biomedicine and biotechnologies, it is therefore important to recognize the main differences between individual and public decision-making. I see four: public decisions are collective, explicitly processual, they are made on different levels of organization, and they are genuinely political.

Taking decisions together means that, as a participant, I am identifying myself as part of a *collective*. This collective can be either a real community of identified others (like my family or in-group), or a virtual community of potential stakeholders. My role as an expert participant is not to make the decision *for* a community, but to assist in a common undertaking to find the best decision for all. I can contribute to this in many different ways, for instance by raising helpful questions, by listening to the experiences of others and helping others to be heard, by asking for evidence to support claims that are on the table, by shifting the discussion to a meta-level, and by discussing the decision-making process itself. Sometimes, as a bioethical expert I can also help by suggesting a potential solution, but very rarely can I help just by arguing for what i personally see as the right decision and by defending my arguments as if i were in a discussion among colleagues. The latter strategy would be a conflation of the individual and the collective. t he approach would be understood by others as if i were publicizing the viewpoint from my personal *forum internum*, and treating the public decision like this would be a generalized version of my individual decision. Others in the field would then be framed as competitors proposing their own solution as i proposed mine, and communication would become mutually defensive and much less constructive than if the group were on a learning track.

Secondly, public decisions are *processes taking place over time*, not events taking place at a given point in time. They are prepared, contested in discourses, and they emerge. Even if they are ultimately taken by powerful individuals fulfilling their executive roles, they are very rarely 'snap decisions' taken in one moment. This difference is closely related to the first, but it is less of a black-and-white contrast with personal decision-making. Like discourse, which can be a common learning process, individual decisions can also – if the circumstances allow it – be essentially perceptive and deliberative processes (on moral perception see Nussbaum 1990, Blum 1994) that involve several steps and loops over time.

Public decisions, thirdly, are *multi-layered*, in the sense that they involve more than one organizational level of decision-making. There is an overlap here with modern theory of governance (Kjaer 2004), which analyzes plural levels, both in institutions and in multi-institutional settings, where steering takes place, rather than the top-down approach of government.

a nd fourthly, the concept of the *political* is broadened accordingly. Wherever the rules of the game are publicly set or managed, wherever control, steering and accountability are sought in institutions and multi-institutional settings, decisions are genuinely political. individuals' awareness of the political dimension of their engagement is essential for any self-assessment of their roles. i agree with Benhabib (2002: 144) that 'political discourse and moral discourse are not identical. Political discourse is a mixed mode in which universal justice claims, agent- and group-relative strategic reasons, and culturally circumscribed ethical considerations, which are relative to "we communities, mix and intermingle".[2]

2 in an earlier paper i have argued on the basis of theoretical considerations that bioethics, if it deals with social rules applicable to more than just one individual, is

t he political process is a mixed mode and the different components do not have the same weight distribution as in individual decision-making.

in all four respects, impartiality is a crucial criterion for legitimacy. But impartiality with regard to recognition of others in the public sphere, the fairness of the decision-making process, the selection of appropriate levels of steering, and the mix of moral and strategic considerations, is different from impartiality in an individual moral analysis.

It is also different from the ideal of objectivity through universality that is sometimes stressed in regulatory bioethical work. This raises the question of how ethical arguments, with their claim of generality (or non-relativity), can contribute at all to public decision-making. If ethical arguments are brought into the public sphere with the attitude that there is only one universal rationality, bioethics itself can become dogmatic and an obstacle to, rather than a facilitator of, mutual understanding. h owever, the end point of a controversy does not necessarily need to be a consensus on the basis of one shared rationality, but moral compromise can be a form of joint moral learning (Benhabib 2002: 145).

t his does not necessarily limit or exclude bioethics from the public sphere, a point i can illustrate with an example from the stem cell debate. in a recent article, Harvard bioethicist Dan Brock addresses what he sees as the main obstacle to a consensus on the use of human embryos for research: the belief of many people that the deliberate destruction of human embryos is morally wrong because the embryo deserves the same respect as a human individual. h e then criticizes this belief as based either on a religious dogma, which, in his view, is 'largely impervious to rational argument', or, if it is secular, as based on weak reasoning. Space does not allow me to parse the normative force of his arguments here (for this, see the critical paper by Deckers 2007). I am, however, interested in its typical form and style. o ne of the arguments for the moral status of the embryo is potentiality. a s Brock (2007: 8) puts it: 'The relevant question for potential's impact on the moral status of an embryo is whether the fact that an embryo has the potential to develop into a human person, even though while still an embryo it is not a human person, is sufficient to confer on the embryo the moral status it will later have after it becomes a human person'. He rejects this using the analogy of a hypothetical case: Sarah has a terminal illness and writes her will leaving her house to her daughter. h er daughter is then potentially the inheritor of the house. h owever, until she actually is the inheritor, not just the potential inheritor, she evidently has no right to sell the house. Like Sarah's daughter, the human embryo cannot be endowed with moral rights before it has the characteristics necessary to qualify for those rights. From this and similar hypothetical cases Brock concludes: 'Moral rights in

accountable politically (Rehmann-Sutter 1991). Now I would broaden this argument by acknowledging that, in political discourses, agent- and group-relative strategic reasons, *together* with moral considerations and cultural values, play a role. t his is sometimes difficult to accept for bioethicists, who tend to defend the view that moral considerations should be superior to and outweigh strategic reasons.

general have this character – they are grounded in the actual, not just the potential, properties of a being' (2007). If this is true and embryos lack the actual properties that confer on them moral rights, the conclusion seems inevitable that they do not have moral rights.

t his argument, however, is based on several tacit assumptions. Firstly, that embryos are individuals, which start their existence outside the moral sphere and acquire their moral status by developing certain intrinsic capabilities that are considered essential for having moral rights. Secondly, that secular philosophical analysis can judge which capabilities are essential. And thirdly, that any ethical responsibility for embryos is based on their individual rights. t here are other views in the debate, which do not share these assumptions. t he view that moral dignity is conferred by g od, or comes with a transcendent soul, or is bestowed on the embryo by a relationship of maternal care, must not be considered irrational because their set of assumptions differs from those accepted by Brock. Each of their assumptions can be explained transparently by providing reasons and Brock's assumptions are no less cultural than those of others. But by discussing these reasons, and by an act of hearing and understanding the reasons that are given for a view that one does not share, the debate shifts to a learning track, can reach a deeper level, and becomes a more sensitive and respectful communicative practice. Despite scepticism over moral rationality, i do not see a reason for excluding such a style of argument, typical of bioethics, from a cross-cultural dialogue, as long as one condition is fulfilled by their proponents: they should not insist that their approach to rationality is the only one possible, and that everything else is by definition irrational and not worth taking seriously. The general validity claim of the arguments, however, is not the problem; the problem is more a claim of exclusivity. g eneral validity claims of arguments can, by contrast, be facilitators of discussion across cultural divides. Without such *general* validity claims, each individual or culture would just express local opinions. Then there would be no appeal to take each other's points seriously, and everybody could just say what she or he liked, without expecting that others would critically examine the framing, the reasons, the conclusions and the implications.

In the example given above, Brock's model of the emergence of moral responsibility for embryos at the iVF–stem cell interface, together with its explicit and tacit assumptions, and the conclusions he draws from them, can be taken both as a question and a challenge. They help to clarify one's own point of view regarding the moral status of extra-corporal embryos and their implications determine *whose* views should decide the ethical legitimacy of spare embryo donation for stem cell research and bring these views into the forum of public discourse.[3]

3 Patients' ethical views and perceptions may differ and be considerably more complex than professional bioethicists' theoretical accounts. See results from our own interview studies in IVF clinics in the UK and Switzerland: Haimes et al. (2008), Scully et al. (in press).

Why ELSA?

in a world of technology there is a tendency to understand the language of communication in instrumental terms: words as transmitters of information, which need to be decoded by the receiver.[4] t his interpretation misses the point h ans-g eorg g adamer has made in his philosophy of language: we do not really understand how language works if we reduce it to a means to an end. Communication is a practice in which the participants realize and live a community. it would therefore not be accurate to say that there is a community which now uses this or that language. l anguage *builds* and *actualizes* a community. l anguage also constructs the meaningful world of those who participate in the language. it would be similarly inaccurate to say that there is a world of existing meanings which then becomes the topic of a language. l anguage and communication bring a world about (Gadamer 1986: 450–454). When we apply these ideas to ELSA, we can say that cross-cultural communication about ethical, cultural and societal aspects of the life sciences builds a larger and more inclusive community, where a relevant aspect of the world is brought about. Biotechnology and medicine (as parts of the social world) were not already there before communication began. However a previous ‘world’ of biotechnology and medicine could have been the world of a smaller group, perhaps an ‘expert world’. Biotechnology and medicine, as they are developed in the broad and cross-cultural context of a meaningful social world, are brought about in language and communication about their meanings and implications. That is perhaps the most salient answer to the question of why we need el Sa research in the life sciences: we need to understand what is going on in our world and our language(s).

This concerns not only decision-making processes. Stressing the point of understanding, e llen Clayton has formulated the aims of el Sa research (in genomics) as follows: ‘Much effort is being devoted to trying to anticipate, understand, and address the ethical, legal, social, and political implications of genetics and genomics. This inquiry is complex. Understanding the social effects of genomics requires an analysis of the ways in which genetic information and a genetic approach to disease affect people individually, within their families and communities, and in their social and working lives. Genomics presents particular challenges with respect to clinicians’ ethical and professional responsibilities, including the appropriate use of genomic information in the health care setting’ (Clayton 2003: 562). She refers to the ways in which genetics affects people individually, within their families and communities, and in their social and working lives. These suggest responsibility, but go far beyond the dilemmas of decision-making that genomics can entail. In order to understand what is at stake in such decisions, and in order to find the criteria for ethically good decisions, a

4 t he *locus classicus* is Shannon and Weaver (1975). See the critical discussion in Manson and O’Neill (2007).

broader perspective on cultural and social implication is a precondition. t herefore, interdisciplinary ELSA research is necessary, and not just work in bioethics.

Bioethicists tend, for their own good reasons, to be sceptical about democratic processes of decision-making. ‘Democratic legitimation is ethically unreliable’ argues O’Neill (2002: 169). Politics, because it is a ‘mixed mode’ of decision-making (see above), may have ethically unacceptable outcomes, or it may not produce what would be ethically required. Ethical scrutiny is also needed to determine the fairness of the process. h owever, certain decisions, such as those related to good governance of international research in reproductive medicine, drug development, genomics, etc., need to be taken in public, and they need to include transnational and multicultural communities in order to be politically and ethically legitimate. o f course we cannot assume that the results of a discourse in the public sphere are always ethical. t he concept of the public sphere, however, with its critical function, can be a normative criterion to assess the ‘quality’ of public discourses.

Anne Fausto-Sterling (2003) speaks of ‘cultural fingerprints’ that can be found in the process of scientific research. But what about the cultural fingerprints in *bioethics*? I am sure that bioethics carries such cultural influences, and would not be possible as an objective, neutral science, independent of culture and language. l iberal individualism, which characterizes large portions of professional bioethical discourse and has inspired its core governance concepts (e.g. autonomy, informed consent), has its roots in Western traditions, and is not understood equally in e astern societies where, for example, assisted reproductive technologies are integrated in ideals of a harmonious society and family consent.[5] Cross-cultural communication can demonstrate the narrow framing of some predominant views in bioethics. Stem cell research presents a bioethical problem, not only in terms of the moral status of the embryo, but also in terms of other, unexpected aspects. in China, for example, the role of i VF within the one-child policy renders surplus the embryos left over after successful i VF, but also enhances the desire for a child and can lead to considerable stress on a marriage in the case of infertility (Mitzkat 2009). Such issues, which are likely to be unfamiliar to outsiders, can be perceived through cross-cultural communication.

i see el Sa research and communication in bio-societies as having a twofold function. Firstly, it works towards *acceptability of biotechnological innovations*. n ot to be confused with acceptance, acceptability includes legitimacy: acceptable practices are not merely accepted ‘in fact’, but are seen as good, helpful, empowering, responsible, etc. by participants, with regard to their culturally-inspired visions of a good life. Secondly, el Sa contributes to the *trustworthiness of science as a generator of progress*. if science and technology legitimize themselves (in their internal vision of what is needed out there in society) according to the concept

5 Xu (2008). I thank Joy Zhang for providing a review of Chinese conceptions of good governance of research that contains this reference. See also Prainsack et al. (2008) and, with regard to China, the workshop and conference reports on www.bionet-china.org.

of progress, there is a clause of trustworthiness. Society has good reason to trust scientists' assessment of societal needs and of the expected benefits from new technologies if, and only if, their internal assessment of what would be good for societies is accurate and in harmony with an independent assessment of societal problems and needs. Both functions cannot be fulfilled by bioethics alone.

Research funding agencies and policymakers may prefer a more pragmatic view of the aims of ELSA research. ELSA should help to keep the gap between science and society from widening, and place or shape technologies in a socially responsible way (*integrative* ELSA). Another reason for financing ELSA activities is to avoid or alleviate potential conflicts over technology (*preventive* ELSA). Some see the main reason for ELSA as lying in finding the limits for socially and environmentally acceptable technology. Human rights (in regulatory approaches) and values of safety (in risk assessment) can also be defended by ELSA (*limitative* ELSA). Each of these pragmatic research policy aims is grounded in ELSA's fundamental purpose of generating social legitimacy and trustworthiness. it is evident that many issues around the biosciences can be treated adequately only from a cross-cultural perspective.

h owever, el Sa also needs to develop a perspective on its own research culture and on its own cultural references. t he mix of disciplines seen as necessary for el Sa differs considerably in different countries. in some nations, bioethics predominates and the empirical social sciences are less developed, whereas in others, the strength of el Sa derives from sociology, cultural studies or science and technology studies (STS) with less weight on philosophical bioethics. Contrasting cultures of ELSA and their roles in public decision-making processes need to be investigated and clarified. ELSA, which can be seen as a reflection loop in dynamic biotechnological societies, itself needs a reflection loop. Its own processes and patterns, and its effects on society, also need to be investigated by ELSA research. If ELSA were reduced to bioethics, decision-making processes (the focus of ELSA) would be under-investigated. Therefore the concept of the public sphere can act as a barometer for good science communication, indicating how well reflective initiatives like ethical advisory committees, risk discourses and ELSA research programs fulfil their social and political roles. It therefore becomes clear that el Sa , as an essentially interdisciplinary and cross-cultural approach, is much more ambitious than either the 'public understanding of science' or even the 'public relation' to science.

Conclusion

i have suggested a vision of deliberative democracy for technology. Discussing the questions of why and for what aims bio-societies need ELSA research was not possible for me without committing myself to a political vision. a socially robust science is not a science that is immune to social criticism and conflict. t he vision is about a different science/technology with a different concept of objectivity. Objectivity, with regard to *technological* practices, is not separate from responsibility (Heldke and Kellert 1995). The scientific-theoretical ideal of objectivity as freedom from bias, where bias is understood as prejudice, has its complement in an idea of practical impartiality in technological decisions, where bias is understood as dependency on particular interests.

t he social responsibility of science can be fostered by science communication. Science projects ideas of social needs and aspirations outwards, but often there are no institutionalized channels for societies to communicate in the other direction, back to science and technology. If such channels are not open there is a risk of misunderstanding, or even non-understanding. A meta-reflection on the social construction of el Sa could therefore pay dividends for science communication. it could help to clarify the ethical responsibility of science communication, both with regard to normative decision-making (practical responsibility), and with regard to understanding and explaining science. t his would help decisions involving scientific knowledge (or promises) to be responsive and reflective. Cross-cultural differences play a role on three different levels: first, the perception, social use and significance of technology; second, the construction of social and ethical issues; and third, how social and ethical implications are investigated (i.e. the social construction of ELSA). On all levels, cultural symbols and metaphors are used, and worldviews and historical experiences are integrated. Cross-cultural el Sa is therefore not comparative el Sa (i tell you what 'we' believe, you tell me what 'you' believe), but a contribution to a more open, international space (Dickins and Salter 2008) for decision-making. Cross-cultural ELSA, done well, is an opportunity to create a transnational bio-political public sphere.

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Chapter 6
Journalism and Society

t oby murcott

Accuse a journalist of bias and you cut them to the ethical quick. Impartiality is a central pillar of responsible reporting. Check facts. Report what you are able to verify. Do so without favour. a nd above all remember the responsibility you have to your audience, since they are relying on you for impartial information.

This is not the only job of a journalist, but it is the one that is most vital in a democracy. a ccurate and impartial reporting is one of the mechanisms for holding public officers to account. In a modern democracy journalists are free to inquire about the roles of public appointees, their spending of public money and their affiliations. In fact it has been argued that democracy is impossible without a free and fair press. The free part of that equation is down to the government of the day (one measure of an open society is how much freedom its government allows to the press), but the fair part is the responsibility of journalists, editors, publishers and broadcasters.

Freedom of the press is a complex and fascinating issue and i don't intend to pursue it beyond the notion that impartiality is crucial to effective journalism. t here are endless discussions to be had about the bias of particular publications and outlets, where to draw the line between fair reporting and intrusion into personal life and so on. Science journalists rarely deal with reports on individuals' private lives or political arguments. Science journalists are almost never sued. t hey are rarely involved in the rough and tumble competition between different publications. t hey do report on controversial topics and, by its very nature, on research that questions established thinking. But by and large they avoid some of the more lurid aspects of journalism, reporting instead on the latest research and providing briefings on the sometimes complex ideas emerging from the world's laboratories. However, the very nature of the job puts considerable pressure on the science journalist to step away from the neutrality of reporting and become an advocate for science itself. While most journalists will, at some point in their careers, write pieces supporting a particular issue, individual or political party, wholesale support of an entire field of endeavour is not journalism, it is priesthood. This is not to say that science journalists are priests – far from it. However, it is important as a science journalist to recognise the pressures in that direction and to understand the ethical need to resist them.

t he press; the media; the fourth estate, have long been accused of having power without responsibility (see Curran and Seaton 2003). They are able to make and break careers, and frequently do: newspapers, for example, boast about uncovering misdeeds and forcing politicians to resign. a slightly more measured view of this power is the role that journalism plays in developing public opinion. Journalism not only reports on events, it shapes them too; something which is perhaps most obvious in politics.

The political interview is a showcase for both the politician and journalist with occasionally startling results. e xamples include (notoriously hard-nosed interviewer) Jeremy Paxman's famous interview of then British Home Secretary, m ichael h oward, on the late-night current affairs programme *Newsnight*. in that interview Paxman asked Howard the same question twelve times. It was, as Paxman said, a simple yes or no question, but Howard gave what many concluded were evasive answers on all twelve occasions (BBC News 1997). While it is impossible to quantify the effect this interview had on Howard's political career, many commentators credit it with being the beginning of the end.

a more recent example is to be found in some of interviews given by 2008 u S Vice-Presidential hopeful Sarah Palin. in these she was unable to name any newspapers she read regularly and was unable to describe the Bush Doctrine, the doctrine of the current incumbent president who was a member of the same party. When she was asked whether she disagreed with any US Supreme Court judgments other than *Roe versus Wade* (a u nited States Supreme Court case that resulted in a landmark decision regarding abortion), she replied that she did but was unable to name any. She was shown to be unfamiliar with the terrain, a point used against her by her opponents. Again, it is difficult to quantify the effect that this might have had, and potentially will have, on her career but it did make the point that she was a poor performer in political interviews at that time.

In both of these cases the role of the journalist was to test the knowledge and debating skills of the interviewees, to shape the public perception of them as politicians and, perhaps, to test their suitability for office.

The shaping of public opinion is also key to another important branch of journalism: criticism. There are arts critics; theatre critics; restaurant critics; film critics; dance critics; music critics; architecture critics and so the list goes on. t heir role is to offer an informed opinion on their subjects and in order to do so they are expected to be experts in their own right. Within each field the most respected critics have a profound influence. Shows can fail to attract audiences and close after being slated by reviewers, whereas glowing reviews can draw in audiences, making careers and fortunes for performers and producers. The critics are not just there to report, they are integral to the development of their subjects.

Similarly, financial journalists can have a significant impact on businesses, not just by reporting on the actions of a company, which can affect the price of its stock, but by opining on strategy and the competence of business leaders. Share tipsters in particular can cause considerable movement in share prices: a real effect in the real world.

a t the time of writing, the u K and indeed the world, is heading into what most predict will be a major recession and there are some commentators who have laid part of the blame at the feet of financial journalists. By talking up the potential problems, goes the argument, they are rendered more likely to happen. The BBC's Business e ditor, r obert Peston, has been singled out for criticism by a number of publications for his role in reporting on bad financial news, particularly his success in breaking stories about the failure of several UK banks, most famously Northern Rock. The accusation is that his reporting of the bank's troubles precipitated a rush of savers withdrawing their money, pushing the bank closer to financial collapse. Again, this is hard if not impossible to quantify and there is, of course, a huge ethical question surrounding the idea that it would have been better for him to keep quiet (which I do not propose to tackle here, but which is discussed further by Fenton-O'Creevy 2008).

a few years ago Steve r ayner, then director of the e conomic and Social Research Council's 'Science in Society' programme, convened a workshop to ask whether science needed a new type of intermediaries too, namely 'scientific connoisseurs'. h e argued that:

> Connoisseurs […] are not themselves practitioners of what they judge, but this lack of practice is not believed to undermine their authority to judge practitioners or to communicate their judgements to wider publics. Given the current public mistrust of many of the processes and outcomes of science and technology, it is pertinent to ask to what extent connoisseurship could (or already does) exist in relation to science, how it could be fostered and maintained, and the role that connoisseurs of science would then have, as public intellectuals, in the wider legitimisation (or not, as the case may be) of particular science-based processes and products. (Healey 2004)

The workshop was attended by academics and policymakers but, astonishingly, not by science communicators who are, in many respects, scientific connoisseurs. Do they, like the critics above, wield the same type of power?

t he power of comment

Many years ago, as I was first starting out in science journalism, I read a salutary modern fable. i have not been able to source it and so cannot say whether it is true or not, and i assume that the version i tell here may have come a long way from the original. But its veracity, or lack of it, does not reduce its impact, or its message.

> A journalist covering the war in Bosnia in the 1990s secured an interview with a sniper (quite a journalistic coup). They met in the sniper's nest above a thoroughfare in a Bosnian town. t owards the end of the interview the sniper spotted two civilians walking down the street and called over his shoulder to the journalist:
>
> 'Which one shall i shoot?'
>
> The journalist recoiled in horror, saying that he was just an impartial reporter, present only to observe, not to get involved, whereupon the sniper shot both

> civilians dead. The journalist, deeply shocked, gathered up his things and backed out of the room. a s he reached the door the sniper turned to him and said.
>
> 'Pity, you could have saved one of them!'

The point is clear. Just by reporting on a subject and interviewing people, a journalist can have an effect on the real world, on real lives. Whether the interviews with Sarah Palin helped Barack Obama become US President is hard to say, but it is clear that an Obama Presidency is likely to make different decisions to a McCain Presidency. Who knows what that might mean for both domestic US policy and world diplomacy. h ow many restaurant critics have been instrumental in causing eateries to close? h ow many t V critics have shortened the lifespan of a new comedy series? These are real effects on the subjects of a journalist's reports.

There is one major exception to this rule: science journalism. Reporting scientific research in a newspaper is presumed to have some indirect, difficult to quantify, impact on funding decisions; however, news coverage of a research project is assumed to have no bearing on the science done as a result of that project. That is decided by whoever picks up the scientific baton and runs with it. The scientific debate is had within the scientific community, not with the wider public, where journalists might have an impact.

There are a number of different angles to this argument and I would like to address each of them, one at a time.

The first is the nature of the material being reported upon. To return to the example of politics, a political debate is normally a discussion of ideologies, or pragmatics to which there is no clear cut answer. t he solutions proposed by politicians are strongly influenced by their own beliefs. A socialist might believe that a just society is based on the redistribution of wealth while a political conservative might believe that this hinders the development and growth vital to a successful society. Data and evidence from a myriad of sources are used to support a politician's arguments. But they are not at the heart of it. Data can be, and are, excluded or reinterpreted to within an inch of their lives. e ach side might produce a totally contradictory set of figures. While they might throw brickbats about methodology and analysis, data play a supporting role in politics, the prime mover is ideology. o r at least a belief that the solution offered has a better chance of succeeding than the one offered by an opposing politician.

Opinion is writ even larger in the sphere of journalistic criticism. It is hard to see what empirically gathered data might be offered to prove the merits of one film over another for example. Critics do draw on their experience and offer comparisons with previous works but the final articles are not just based on opinion, they are opinion.

The scientific method seeks to eliminate opinion as far as possible. It does so in a number of ways. The first, informal, step in this process is made through collaboration and coffee room discussion. The vast majority of scientists will work alongside colleagues with whom they will discuss their work and from whom they will seek advice. One of the acknowledged roles of colleagues is to spot errors in experimental design, unintentional bias and the like.

t hen the research might go through a more formal level of scrutiny as a presentation to a conference of some sort. it may be a small-scale meeting within an institution or a larger gathering of scientists from around the world. a gain, one role of the audience is to pick up on errors and suggest different, better, methodologies and interpretations.

if a piece of research survives these steps then it will, in all probability, be offered to a peer reviewed journal for publication. I will return to the subject of peer review later in this chapter, but for the moment i want to concentrate on just one aspect of it. Before being accepted, each paper will be refereed by other experts in the field, normally with two or three independent opinions being sought. If it passes this hurdle it will be published, and then other researchers in the field will attempt to reproduce the results, providing yet another, relatively independent check and balance on the data.

The majority of science journalism is conducted at the point of publication. t he data will already have been carefully examined and therefore the role of the science journalist is to report – not to scrutinise, and certainly not to opine. Unlike the political journalist, or the critic, or the financial tipster, the raw material of a science journalist's trade has, to a large degree, already been tested. A political opinion is put into the public domain to be modified, debated, argued over and turned into something that will, ultimately, win votes. Likewise a critic's view of a particular spectacle, or a sports reporter's write up of a contentious refereeing decision. These are flexible and fluid; they can and will be modified by public perception. a nd while there is the perception that reporting science in the news is a good thing, any debate that follows will not influence the data that has already been gathered and assessed. A science journalist has little if any impact on the scientific data gathered, unlike almost any other branch of journalism.

Journalists as expert commentators

The next factor I want to consider is the ability of science journalists to comment on the research that emerges from the world's laboratories and research institutions. As discussed earlier, many journalists are considered experts in their field and would be expected to provide expert comment. a football correspondent would be required to be able to comment on the skill of an individual player, team or coach, an arts correspondent on the technical abilities of a sculptor, a restaurant critic on the aptitude of a chef. t hese opinions may well be challenged by those criticised and other journalists, but the basic right of the journalist to offer them will not be challenged.

a s already discussed, the science that reaches the news has already undergone considerable scrutiny. While there is always room for more, and science is set up to constantly check and cross check results, it is extremely rare for a science journalist to be in a position to act as an expert reviewer in the way that so many other journalists are.

The main reason is expertise. Scientists undergo rigorous training that requires dedication and immersion in their chosen topic. it has been said that, as they progress, they know more and more about less and less (Gallagher and Appenzeller 1999). The degree of specialisation and expertise within science can be extreme. It is common to find two senior professors in apparently similar fields, say genetics, who may be remarkably ignorant about each other's work. They may well have a good grasp of the basics and use common principles and techniques, but, crucially, they would not consider themselves as expert reviewers for the other's research. a s soon as you cross disciplines you find huge gulfs in understanding: a cosmologist is no more likely to have a detailed understanding of population biology than a prima ballerina, an international centre forward or a m ichelin starred chef.

Consider, now, the position of the science journalist. I am regularly asked by scientists I talk to whether I specialise in a particular area of science. When I tell them that I will tackle anything that might loosely be considered science they are very occasionally impressed. m ore often than not they are surprised, with a touch of scepticism for good measure (see Strauss, this volume).

So, while a cricket correspondent may have the expertise to discuss a failing batsman's technique, a science journalist cannot hope to get close to that level of review for their entire patch. t o criticise science, it is considered, at least by the scientific community itself, that you need to have expertise within the field close to that required of a peer reviewer. A full-time science journalist will never have that expertise. While they might for a short time, if they leave research and take up journalism, the pressures of the job will mean that they lose touch with the cutting edge of their discipline remarkably quickly.

i have a PhD and three years of postdoctoral research under my belt in biochemistry. For a brief moment i was arguably a world expert on the pyruvate kinase enzyme from the baker's yeast *Saccharomyces cerevisiae*. t hat was in 1993. As a crude experiment, I have just searched *Google Scholar* for the terms 'pyruvate kinase saccharomyces cerevisiae'. My own published papers were way down the list and i do not recognise the names of most of the researchers in the field. I am hopelessly lost in the only area of science in which I ever had any claim to being a peer reviewer, and i am certainly incapable of being an expert critic of research in any other scientific field.

Now, there is more than one type of criticism. I am talking here about a high level of specialist scrutiny of the details of research. A political journalist would be expected to be able to read, grasp and, above all, critique a government white paper. Likewise, a financial journalist would be expected to do the same for a company report and a tennis journalist would be expected to break down a game into its different elements and discuss them. t his is partly because white papers have a similar format and language regardless of the content, as do tennis games or financial reports. The challenge for a science journalist is that a paper on molecular genetics looks radically different to one on particle physics.

There is another element to this level of critique and understanding. Most areas of journalism cover areas that are, to some extent, played out in the public arena: sports, politics, arts, finance, conflict, and so on. This means that there is often a large body of existing work to refer to, plus analysis and comment to inform the journalist of the day. However, this is much less often the case for science, paradoxically because science has openness built into it. A scientific career depends to a large extent on the quality and quantity of research published in the public domain, accessible, in theory, to all.

t here is one important obstacle to full transparency that should be mentioned. Most journals are in part funded by subscription. You have to pay to read the entire article. But most article abstracts are available on such databases as *Pubmed*. t his at least gives an outline of the research and identifies the researchers and institutions involved. In theory at least, anyone with a reasonable level of knowledge (perhaps an undergraduate science degree) and access to the Internet, can get a very good idea of who is pursuing what research and where. A journalist will normally be given free access, but his or her audience, the general public, will not be able to read the source material.

This, though, applies only to research that has been published. It is significantly harder to find out what research is in progress, particularly in private institutions. But this is no different to a financial journalist seeking information on the activities of a particular company or a political journalist trawling the smoke-filled rooms of a political convention in pursuit of a story. In other words, it is just classic investigative reporting territory.

t he diverse nature of science now re-enters the picture. t he range of research carried out under the banner of science is enormous. a football reporter may have to know a huge number of details and have great contacts, but they are not going to wake up one morning and discover a newly created side that has just won a major trophy. They will see it coming. A political reporter will be surprised by some breaking story but they will not wake up to discover a completely new Prime m inister in place with no warning.

Shifts of this magnitude can and do happen to science journalists. The huge diversity of topics covered, together with the fact that most science is done away from the public gaze, means that surprises do happen. it can be exciting and is always interesting, but it once again shows the difficulty of expertise within science journalism.

t he second draft of history

A central pillar of scientific scrutiny is peer review: the process by which a scientific paper is reviewed by independent experts in the field before being considered for publication. o ften it is also applied to grant applications, with referees' comments sought to advise the grant-awarding authority. it is also an important rite of passage for scientists when they are asked to peer review, they know that they are becoming established within their field and their expertise is being recognised.

The process is simple. A paper is submitted to a journal, or a grant application received by a funding body, and the appropriate editor selects one or more referees to read it. t he exact number of referees varies but two is common. t hey submit their comments and the editor then makes a judgement on whether or not to publish. if there is disagreement among the referees then an additional reviewer may be consulted. t he process is normally anonymous, a feature that is often held up as essential so that the peer reviewer can say what they truly think without fear or prejudice to their own career. Consider, for example, the situation of a middle-ranking researcher asked to comment on the work of a senior member of the field. If their comments were not anonymous, they may show some conscious or unconscious bias which would, ultimately, do no-one any favours.

At the time of writing, peer review is the subject of considerable discussion. A few new models are being tried out and i suspect the process will slowly evolve. The one aspect of peer review I want to consider briefly here is the effect it has on the practice of science journalism.

t he point i have been labouring is that the very nature of science and its practice either excludes science journalists or makes it harder for them to hold scientists to account in a fashion similar to that with which many other journalists scrutinise their subjects. It also means that a science journalist is not part of the process of science in the way that, say, a theatre critic is part of the process of theatre. Peer review, while being an essential part of science, also, inadvertently, helps to perpetuate this exclusion. in politics, ideas are appraised in part by public opinion. The appraisal of peer review is frequently hidden and normally anonymous.

it is common for referees' comments to be sent to the authors of a paper before publication for comment. This can improve the quality of the published research in a number of ways: by allowing the authors to clarify ambiguities, by allowing them to refute any misconceptions on the part of the referees, or by allowing them simply to see the points that the referees thought significant. What is not common is for these comments to be made more widely available. it is not as if referees' comments are hidden or kept under metaphorical lock and key, just that they are not disseminated.

The inadvertent result of this is that the science journalist reporting on the published research is lacking some of the context of its genesis. Whereas the progress of legislation from idea to being signed into law is conducted in the public gaze, science is less visible. While not deliberately hidden, the first time a major piece of work is noticed may be when it is published in a journal of note as a finished product. More research will inevitably be needed in the subject but the publication itself is presented as a mini *fait acompli*.

t he effect of this is to highlight the fact that the process of science is done within the scientific community and there is little, if any, role for public debate about the practice of the science itself. in this context, the role of the science journalist is restricted to reporting and clarifying for a general audience. Journalism is often described as the first draft of history. This opportunity is almost always denied to science journalists. They are presented with at least a second draft and simply required to tell a wider audience what it contains.

u psetting the balance

The concept of balanced reporting is drummed into journalists from a very early stage in their career. i f you are presenting a point of view, it needs to be balanced by an opposing opinion. t his is most obvious in politics. a government might, for example, issue an opinion paper on a particular subject as a precursor to introducing a new piece of legislation. t his will always be reported alongside the comments of the opposition parties, and indeed any particular interest group. t o fail to do so will, quite rightly, bring accusations of bias. This then is balance: reporting at least two different perspectives on the topics from two interested parties, something which is crucial for public debate because it is reporting on the debate itself.

Balance does not always come within any particular item. For example, it is common practice to have an interview with a politician followed by a separate comment from their political opposition. The key principle is that in the overall coverage of the subject, a balance of views is presented.

t his principle is extended to all other areas of reporting. in the arts, for example, it is common to hear two critics differing over the merits of a particular painting. o r two football pundits commenting on the relative merits of a particular footballer. The concept of balance is deeply embedded within the practice of journalism.

So it is no surprise that balance is required in science journalism. If a scientist presents a particular set of results, or an interpretation of those results, then the natural instinct of a reporter will be to find someone else to present the other side. a nd while this instinct is a good one, it can actively distort the reporting of science and can, on occasion, lead to real harm.

Perhaps the best known example of this in recent times was the concern raised about the triple vaccine for Measles, Mumps and Rubella, known as MMR. It has been extensively discussed in other publications and is a well known example. It is, though, an excellent one and I ask for the reader's forbearance as I roll it out again.

In 1998 Dr Andrew Wakefield of the Royal London Hospital gave a press conference in which he told the media of his concern that the mmr vaccine causes incidences of autism in children. t his was, unsurprisingly, leapt upon by the press and became a very big story that ran in different forms for several years. in the press, on radio and on TV, Dr Wakefield was given time to express his views and this was balanced by another expert arguing that the evidence for a link was extremely weak and all the other research pointed to no link at all. Since then there has been considerable further research, and the evidence today is overwhelmingly on the side of no causal link between MMR and autism.

t he point i wish to highlight with this example is how balanced reporting can veer towards misrepresentation of a story. it seems eminently reasonable that Dr

Wakefield's views were balanced by an opposing view. Indeed it would have been deeply irresponsible to do otherwise. But the problem lies in the nature of the debate and the nature of the evidence.

For research to be published it has to be scrutinised by experts in the field. The quality of the experiments are assessed, the rationale of the analysis picked over. a ny claims that cannot be supported are discarded. a ny ambiguities are challenged, and if the research is considered sub-standard it is not published. t he aim is to remove, among other things, ideology and opinion, two of the principal elements of political debate. This process is not perfect but the key difference between scientific evidence and political debate is that the scientific evidence has been independently tested and scrutinised.

The discussion about the potential link between MMR and autism was, by and large, presented in the media in the same way as a political debate. t wo opposing views are presented, leaving the audience to make up their own minds about which side to believe. But that is not what the scientific debate around MMR is about.

The question for science is the validity of the evidence. At the time of the original story, the evidence for a link between MMR and autism was weak. Wakefield had examined a handful of children; whereas, there already existed far larger studies that had failed to show any correlation between the vaccine and the condition. The scientific consensus said that there was no link. The evidence against a link was strong. It had been tested by independent researchers in independent laboratories. The evidence for a link was poor, having been tested by only one group of researchers on a small number of patients. t his does not mean that Wakefield was wrong in reporting his concerns or that he was doing anything wrong in bringing it to the public's attention. t he problem is that balanced reporting, presenting the discussion as if the two sides were equal but opposing, was in fact unbalanced because they were not. t he discussion is about impartial evidence and its interpretation, not a value system or ideology.

t here is a great deal more to be said about the mmr story, not least the fact that there has been an upsurge in the incidence of measles due to parents' reluctance to vaccinate their children. it is a fascinating study of the relationship between science and the media and i would heartily recommend reading more about it. However, this is as far as I want to go with it here. The journalistic concept of balance was in this case totally unbalanced. t his has also been the case with the debate over global climate change (for a brief summary see Boykoff and Boykoff 2004; Lockwood 2008). The scientific consensus has been seen as a point of view rather than a set of exhaustively tested hypotheses, probably as impartial as it is possible to get. in fact it is a common tactic of those who want to discredit climate change that they accuse its advocates of being part of a cabal, consciously lying for political ends rather than presenting well tested science.

For a science journalist this produces something of an ethical dilemma. The tried and tested journalistic principle of balanced reporting can, if applied uncritically, result in dramatically unbalanced reports. t he ethical approach has to be to ensure that the discussion centres on the evidence: to make the audience aware of the context of the discussion, of how well tested the new idea is, and of the body of evidence there is against it. Is it likely to be taken as a political debate of ideologies rather than a testing of evidence? in addition, there is a twist: all new ideas start out small and most are contrary to the scientific consensus. The majority will fail, but some will succeed. This is science in action. There is no way of knowing which ideas are going to make it and it is important to report them all.

It's just journalism

By this point the observant reader will have noticed a serious omission. t he basic tools available to a science journalist are the same as those available to any other journalist: the careful cultivation of a large and diverse contact book, the ability to pick up the phone and seek the opinions of independent experts from particular fields, and (depending on the legislation of the particular jurisdiction) the use of freedom of information requests. While they may not be an expert in any particular field, a halfway-competent science journalist will be familiar with the process of scientific research and have a good idea of how to pick a particular story apart.

t hen there are the myriad of searchable databases, both of press cuttings and of scientific publications, for those in pursuit of background and contextual information and the simple gut instinct that comes from being immersed in a subject day in and day out that allows journalists to spot stories that may not be obvious to others.

Science journalists are just as adept in the use of these tools as other journalists. They may not be experts in cosmic microwave background radiation, but they know someone who is and how to get hold of them. They may not know how a particular discovery was hit upon, but give them a phone and in twenty minutes they will track down someone who can fill in the background details.

I am not arguing that science journalists are unable to practice as other journalists. It is just that the nature of their patch puts a unique set of pressures on them. Pressures other journalists may not understand or even know about.

Conclusions

To briefly summarise then, the practice of science is done away from the public gaze and its first exposure to a wider audience is often as a relatively complete piece of work. In this situation, the most common in science journalism, the role of the science journalist is to report on the research and act as an interpreter for a general audience.

t he practice of science is, by and large, unaffected by public debate. a scientist will not expect to have their day-to-day work publicised and change what they do depending on opinion polls or a difficult to define 'public opinion'. The future direction of research *can* be influenced, normally by changes in the distribution of public funds, but the nitty gritty of the research itself is almost exclusively under the control of scientists and any supervisory bodies they may have. This is in stark contrast to politicians or artists, who are dependent on public support and appraisal for success.

The appraisal of science is done within the scientific community through both formal and informal peer review. Whether science is 'good' or 'bad' is something that is decided by peers and colleagues, not by public approval or debate. h ere i am not referring to the social implications of the research, such as human cloning or development of nuclear weapons, but to the quality of the research itself.

As a result, science journalists reporting research on a day-to-day basis are confined to description and interpretation. What they write will have no impact on the research they cover. They may influence the future direction of research, in some difficult-to-quantify way, but no scientist will make changes to their experiments based on a news story. t rue, the news may alert scientists to relevant research, but any changes they make will depend on their interpretation of the research itself and not on the news item that reported it. A journalist's coverage is not required in order to improve the quality of science.

t his is, to all intents and purposes, the description of a priest. Someone who takes (at times confusing) information from a deity and interprets it for a lay audience but who has little or no impact on the activities of the deity itself and who is not actually needed for the deity to continue on its chosen path.

Displacing the priest

For me this is the primary ethical challenge for any science journalist. It is crucial not to fall into the trap of being an advocate for science (see also, from a slightly different prespective, Larson, this volume). It is something that took me a while to learn. My first moves towards science journalism were motivated in part by a desire to 'do science better in the media'. a nd i'm not alone; informal conversations with many of my colleagues over the years have turned up similar desires. t his is not to be confused with being interested and excited by science. i would argue that a high level of interest in science is essential. But it is, in my view, crucial to make constant internal checks to make sure that an element of criticism is developed and maintained.

Which brings me to the real meat of this chapter. g iven the constraints of science journalism, how can a science journalist hold science and scientists to account? Perhaps the first question is: Should they hold them to account?

t here is a simple answer to this. a ny scientist who receives public funding should expect to explain and even justify their research to their funders, the public. a nd then there's a more nuanced answer.

Much of science is carried out with the aim of improving life. Be it tackling disease, reducing the burden of heavy labour, or simply making more believable movie special effects. Most scientists when asked, and I have asked a fair number, carry out their research in the belief that it will have benefits for others, beyond their own curiosity and career. t hat is to be applauded.

However, it is not enough to emerge from a laboratory and say ‘look at this, I’ve done a good thing for you.’ The claim about the benefit of a particular piece of research is judged by wider society and will likely involve factors the scientist may not have considered. a cancer drug may be greeted with general approval, but to a strident anti-vivisectionist the use of animals in the research may negate the improvements to cancer patients. Genetically modified crops may increase yields, but a significant number of people are opposed to their use in any circumstances.

For these debates to be had in full, more is needed than just the results of research. The process of research needs to be discussed, as does the background and the context. i would argue that it is the ethical responsibility of a science journalist to bring this discussion to a wider audience. The question is how.

much of the answer is not about ‘do this’ or ‘do that’ but about nuance and approach. It is about attempting to provide context, background and relevance and about reporting how science is made and not just the results. This is nothing new to journalism; it is just that, as I have laboured to illustrate, doing this in the context of science journalism has particular challenges.

I would like to start with a reappraisal of what balanced reporting means for science. t he controversy over the mmr vaccine should never have been presented as a debate between equal ideas vying for supremacy. It was not. Instead it was something that occurs regularly in science, is crucial to science and is definitely worth reporting. it was a situation where a small study with a small dataset perhaps picked up an anomaly in the scientific consensus of the time.

Wakefield’s findings were worth reporting. But they needed to be reported as a very small study showing something different to a very large set of well tested data. It should have been made clear that the evidence he presented was weak and needed reproduction and much further testing before it could even be considered as a demonstrating a genuine link between the MMR vaccine and autism. It should have been emphasised that the current evidence did not support the hypothesis.

t his can still be exciting reporting because this is reporting on how science works. New ideas appear, which are often completely at odds with the current consensus; they are tested by others and if they survive then they gradually become the dominant hypothesis. All scientists understand how this works, as do all science journalists. Controversies such as the one surrounding the MMR vaccine should be seen as an opportunity to expose it to wider audience.

However, this is not an easy task, particularly in a short news piece. Some will argue that it is irresponsible to give credence to stories such as the mmr controversy as they might persuade individuals into potentially harmful actions (or in this case, inaction, with parents choosing not to vaccinate their children). t his is, though, both patronising and priestly. t he decision about what to report is that of the journalist and not that of the scientist or doctor. A priest does what the deity decrees, a journalist jealously guards their independence.

I would also like to take this opportunity to argue for a reform to the peer review system that, i believe, will serve science well in the long run. a fter practicing science journalism for the last fifteen years in print, radio and television, I now believe that the anonymous comments of referees should be published alongside peer reviewed articles. a lthough they need not be included in print editions, these comments could perhaps be an online-only feature of science journals.

This would open up the scrutiny that science asks of itself to a wider world and allow journalists to discuss the process of science as well as the results. Probably nine times out of ten, or even ninety-nine out of a hundred, it would reveal nothing of any great interest. h owever, every once in a while, there would be an insight worth publishing, perhaps uncovering a vital debate at the heart of a particular subject that would otherwise have remained hidden.

i anticipate considerable resistance to this idea, perhaps casting it as washing dirty linen in public, for example, or as a slippery slope that would lead journalists to pick up on internal fights best kept within the scientific community. However, the referees' reports would only be made public once a paper had passed muster and been published. t he arguments in the comments would have been dealt with and the process by which they had improved the quality of the research would be illuminated. if science needs more recruits, and this is a common refrain, then let us show it as it is: an exciting, competitive, dynamic, human activity, not an otherworldly pursuit into which people disappear to emerge occasionally, offering pearls of wisdom to a grateful public. if anything can humanise science then surely it is by making visible the internal dynamics of this endlessly fascinating pursuit.

My final point is to return once again to the notion of priesthood. Science does not need priests. Science does not need defending. Science is not under threat. ideas may be discounted for a whole variety of ideological reasons, but the enormous body of scientific knowledge will not vanish in a puff of smoke if someone disbelieves it. Science works: it produces real and significant benefits and, though perhaps not always nor in every single way, it makes people's lives better. With a very small number of dishonourable exceptions, scientists use their knowledge for the overall benefit of humanity. Granted it might be hard to see the advantage we will gain from a new brand of washing powder, but the same has also to be said of sport, art and many other human activities.

What science needs is integration. if it is treated as a deity, as something delicate needing careful preservation and belief, then it risks going the way of deities and being displaced by other, more appealing beliefs. instead, if it is discussed, challenged and scrutinised like every other aspect of human activity, it reveals itself as it really is: simply a formalised version of human curiosity, something as integral to our species as sex, hunger and dispute. The ethics of science journalism are simple: show it to be human.

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Chapter 7

Science Communication and ethics – trying to get it right: the Science media Centre – a Case Study

Fiona Fox

Introduction

> Politicians who complain about the press are like sailors who complain about the sea. Sometimes the sea is calm, sometimes a little bit choppy and, from time to time, tempestuous and battering. however, this has to be accepted as the main fact of the world we live in. (David Lloyd George)

Lloyd George's sentiments about politicians and the press were reflected many years later in relation to scientists in the conclusions of the hugely influential House of Lords Select Committee Report on Science and Technology (2000), which gave rise to the setting up of the Science media Centre :

> the current high level of media interest in science-related issues is to be welcomed. While it sometimes makes for public dialogue in terms which are unsatisfactory to some of the players this is still much better than no dialogue at all. Scientists must indeed take the rough with the smooth, and learn to work with the media as they are.

The Science Media Centre (SMC) is a unique experiment in a new kind of media relations activity. It is a press office that is completely independent, eschews PR and has no brand or institution to promote. Instead, it works on behalf of the whole of science to improve the quality of the reporting – and thus the information the public receive – when science hits the headlines. The Centre's official philosophy that 'the media will "do" science better when scientists "do" media better' mirrors the above sentiments and those of the BBC's veteran science reporter Pallab ghosh who has long called on scientists to 'get off the sidelines, learn the rules of the game and get on the pitch.'

in this chapter i lay out the philosophy, values and approach to science media relations that the SmC has developed since it opened for business in april 2002. I and many others believe the Centre has had a huge influence on the coverage of science in the media and perhaps more significantly, has contributed greatly to creating a new culture within science, which regards engaging with the big topical controversies in the media as part and parcel of the scientist's role.

What i do not have the space to do here is present the thousands of examples of science stories that we have influenced or indeed generated, and I would therefore urge readers to consider this chapter alongside a visit to our website, which shows how we have put our philosophy into practice on a daily basis for the past seven years (http://www.sciencemediacentre.org).

h istory

House of Lords Select Committee Inquiry

The SMC has its roots in the House of Lords Select Committee Inquiry into Science and Technology (Science and Society), reported in February 2000. The backdrop to this inquiry was the BSE ('mad cow disease') affair during which leading commentators had started to openly challenge the authority of science, placing the scientific community alongside other institutions like the Church and the family that were suffering from their own crises of trust. it became clear from the evidence presented to the Committee, that, while scientists were getting better at speaking to trusted journalists working for specialist science media like *Horizon* or *New Scientist*, they were still struggling to engage effectively with the demands of a hungry, often brutal, 24-hour news machine splashing on a science story that had become the subject of national controversy. The need for scientists to get better at the latter was summed up in the conclusions of the r eport as the 'great challenge', and recommendations called for new resources and leadership to focus on this specific and crucial area.

The first person to step up to provide those resources and leadership was Baroness Susan Greenfield, Director of the Royal Institution, who believed that the ri 's historic role of disseminating science to the public, combined with its independence from g overnment, made it suitable to lead any new drive to improve the media's coverage of science. Baroness Greenfield set up an Advisory Committee (Science Media Centre Consultation Report 2002) comprising leading scientists, journalists and editors who over the course of a year in 2000–2001 delivered the concept of a SmC, which would 'help renew public trust in science' and bridge the gap between the cultures of science and the media.

Funding and governance

A number of bold decisions made by the Advisory Committee defined the core principles of the Centre, namely:

> …that the Centre would be independent from any one scientific institution and therefore officially operate on behalf of the whole scientific community.

> While the Centre would be housed within the r oyal institution it would operate independently from the ri with its own governance structures;

and

> …that the funding for the Centre would reflect the principles of independence seen as critical to earning and keeping the trust of journalists and scientists alike. a s such the decision was made to put a cap on all donations ensuring that no one sponsor can give more than 5% of the overall running costs of the Centre. In addition it was agreed that the Centre would make it clear that the Centre is independent form all its sponsors and that all donations are unconditional.

As a registered charity with close links to, but operational independence, from the ri , it was agreed that the Sm C would be governed by a Board of a dvisors – made up of influential scientists, editors and media relations experts – in addition to calling on a list of leading scientists who agreed to sit on the Centre's Scientific Advisory Panel. Funding was and continues to be sought from the SMC's key stakeholders: scientific institutions, science-based companies, media owners and the g overnment.

The director

The legacy of poor relations between science and the media made it difficult for the Committee to find a founding Director with both the scientific credentials and extensive experience of media relations they asked for. Baroness Greenfield frequently re-tells the story of my interview, which she had originally objected to on the basis that I had no scientific qualifications. She then tells how I won the unanimous backing of a panel consisting of ten eminent scientists, including several l ords and l adies, who agreed with her that a passion for and commitment to the issues, alongside my background in media relations were what would make the Centre work. We then ensured that the two members of staff I recruited had the scientific credentials deemed necessary for the job. In 2009, the SMC has grown to a staff of six – myself included – with a range of experience in science and academia, and media relations, and we find it's a mix that works very well.

The consultation process and emerging focus

It was clear when I took up the position of Director in December 2001 that a period of intense consultation was needed to flesh out the specifics of what was originally an incredibly broad concept. Baroness Greenfield's widely reported vision that the Centre would be 'unashamedly pro-science' and 'help renew public trust in science' went some way towards positioning the Centre, but said little about what it would actually do and there were plenty of scientists, journalists and press officers lining up to offer their advice about what was required.

In the first weeks of consultation with key stakeholders, it sometimes felt as though every individual we approached had different and often conflicting ideas about what the Centre should do, with leading scientists encouraging us to focus on issues from improving the science in gardening programs to acting as a base for visiting science reporters from overseas. But after three months of consultation a clear consensus emerged about the weak spots in science media relations where the Centre could make the biggest difference.

This consensus revolved around the very same weakness identified in the h ouse of l ords report referred to as the 'great challenge' – the apparent inability of many in the scientific community to react quickly, confidently and effectively to breaking news about controversial science stories. I leave the philosophical discussions about the 'Two Cultures' for others to debate, but suffice to say that even a cursory glance at the way science operates reveals the gulf between the needs of science on the one hand and the news media on the other. Having worked for campaign groups and charities in the past, i can honestly say that it is hard to imagine two disciplines with as little in common as science and the media. Described frequently as 'poor bedfellows' and a 'bad fit', it often feels as though virtually everything one does is antithetical to the other. Simon Pearson, an e ditor on *The Times* and member of the SmC Board, once outraged an audience of leading scientists at the r oyal Society[1] with his description of the central truth of journalism:

> There is one basic truth about journalism. Ask the question: 'Do you want it good, or do you want it now?' a nd there is only one answer.

Compare this to the process of science where in their search for evidence, scientists spend months or often years researching scientific issues in great detail, waiting for further months while their work is reviewed by their peers before publication.

This culture clash – at its most intense in relation to breaking news – raised its head throughout almost all discussions with key stakeholders. Almost every journalist admitted particular difficulties finding scientists to speak to when a controversial science story broke, press officers repeatedly emphasised how hard they found it to convince scientists to drop everything to engage with a breaking story on their area of expertise, and scientists admitted that while they were happy to speak to trusted specialist reporters like Roger Highfield from the *Daily Telegraph* (now at *New Scientist*), they were reluctant to drop everything to appear live on air and engage in debate in the heat of a media storm.

t he combination of the h ouse of l ords r eport and the SmC's Consultation r eport gave the Centre a strong mandate – to position ourselves as specialists in the controversial science stories that hit the headlines. a s a result, the Centre developed its strap-line, 't he Science m edia Centre, Where Science meets the h eadlines', and our singular and unswerving focus in this area has been one of

1 Taken from speech by Simon Pearson to the Royal Society.

our greatest strengths, allowing us to focus our limited but unique resources in an arena where others had previously failed. Seven years later, it has allowed us to build up an incredible bank of expertise and skill in dealing with controversial science issues in the media, which is now used to great advantage by the scientific community.

This focus on breaking news and controversy within the UK science media environment is key to understanding the SMC. While many initiatives fail because it is not obvious what problem they need to solve or what their role is, the role and position of the SMC are clear, unique and very specific. The Centre is part of a broader effort to overcome the cultural clash between science and news, and its role is to work with the scientific community to adapt the very best science to the demands and needs of the news media when controversial stories arise.

The scientists, journalists and press officers approached during the consultation were in no doubt as to the kinds of stories that needed the SMC's attention; they were those such as gm and mmr . Just months after the h ouse of l ords Select Committee began hearing evidence about the way the media covered science, gm crops exploded onto the headlines with tabloid front pages screaming out 'Frankenfood'. Furthermore, throughout 2001 Tony Blair's refusal to confirm whether his young son l eo had been vaccinated with mmr fuelled the media row over a possible link between the jab and autism. There is no room to consider both stories in detail here, and much has already been written about the way scientists and the media dealt with both stories, providing useful insights (see Po St r eport 1998; Boyce 2007). However, it is fair to say that almost all those involved in these issues felt that one of the key roles of the new SMC would be to work with scientists to enable them to engage more effectively with headline stories, which in the hands of effective campaigners and a sensationalist media had become some of the most contentious issues of our times.

The influence of the GM debate

Visits to plant and agricultural science institutes in early 2001 were to inform the values and philosophy of the Centre very profoundly. At world organisations like the John innes Centre (e urope's premier research centre in plant and microbial science), Rothamsted Research (the largest agricultural research institute in the United Kingdom) and IGER (Institute for Grassland and Environmental Research), we met a succession of the scientists who knew more than politicians, campaigners and journalists put together about this new plant breeding technique – they were the real experts. Yet, with a handful of exceptions, they had remained silent in the national media debate on gm . t here were many reasons why, but looming large was the fact that these mild-mannered scientists were bewildered by the nature and size of the debate. Few journalists, especially from tabloid populist media, had ever shown any interest in the finer points of their research before, and the prospect of dropping their research for several hours to take part in a potentially hostile interview with an anti-GM campaigner on breakfast television news in front of millions was a completely alien one.

The vacuum left by the failure of the best experts to engage was quickly filled by a mixture of politicians, campaigners, protest groups, representatives of the GM Industry, columnists and high-profile scientists, who were not necessarily the true experts in this area but felt compelled to wade in to defend science. t he views of these groups are of course all legitimate and formed a critical part of national debate, but what was missing were the experts – the scientists who had actually developed the techniques and who were involved in numerous research projects to identify risks and benefits, strengths and limitations.

Those who have heard me speak on this subject will be well-accustomed with my verdict on the GM debate but I make no apology for repeating it as it lies at the heart of the role of the SmC. i genuinely do not care whether the British public say no to gm as long as they do so after access to a balanced, accurate and informed debate in which the best plant scientists have had their say. h erein lies the basis for the SMC: it is our job to ensure that never again will the UK have a national media debate about an area of science without the best scientists taking up their rightful part in that debate. if at the end of discussions the u K still says no to gm then that is simply a healthy democracy.

In some way the GM debate also influenced the values and philosophy of the SMC, and for that we can thank Tim Radford, much loved former *Guardian* Science Editor and fellow contributor to this book (see Radford, this volume). During his evidence to the h ouse of l ords Select Committee, r adford surprised some by arguing that the media frenzy on gm crops should have been enthusiastically welcomed and embraced by plant scientists as a ‘wonderful chance to educate the public about this new technology’. it was clear to him and also to the newly-formed team at the SmC that the debate could have played out very differently if the best plant scientists in the country had viewed it as an opportunity rather than a threat. From this point onwards, the SmC set out its stall to change the culture within the scientific community so that future headlines would be viewed as just that – a golden opportunity.

Engineering at the SMC

About a year into the life of the Centre I was invited to present the SMC’s work to the g 15, the self styled ‘g 8’ of the engineering world representing the Chief Executives of all the UK’s top 15 engineering institutions. Unbeknown to me there were moves afoot to set up an e ngineering m edia Centre based on the SMC but apparently my presentation persuaded the majority of institutions that the SmC was already doing engineering, albeit not using the word as much as some engineers would have liked! The engineering community offered to fund a dedicated engineering press officer in the SMC, and slowly the Centre has become passionate about ensuring that engineers have their voices heard on some of the biggest stories of the day, including the role of nuclear power, the energy gap, the solutions to climate change and the increasingly important role of engineering in medicine, computing and infrastructure.

The SMC as an international model

o ne exciting development that was not anticipated at the outset is the level of interest in imitating and adapting the model of the Sm C in other countries and on other subjects. I am regularly visited by people exploring the possibility of setting up versions of the Centre for manufacturing, arts and humanities and the social sciences. m any of these have not come to fruition, partly because the problem they are solving is not as clearly defined as the problem of the scientific community's failure to engage effectively enough with the news media. h owever there has been huge success in the international arena, where we now have Sm Cs in a ustralia, n ew Zealand and, soon, Canada. Watching these Centres start out – closely based on our model – and then make their own way adapting to their own very different local contexts has been fascinating, and we anticipate more Sm Cs in e urope and the u S in years to come.

h ow the science media centre operates

The basics

The SMC has worked closely with journalists, press officers and scientists to develop a number of services which are effectively delivering our goals. t hese include our database of media-friendly scientists, r apid r eaction service, r ound-Up press releases and our regular press briefings. The following is a summary of these activities, the latest examples of which can be found on our website.

The SMC database of experts

The SMC's database is not quite like any other database of experts. It is not a searchable database for the media to use, but a resource for the SMC to find the right expert on the right subject within the right timeframe. Scientists and engineers are selected not just for their proven expertise, but also for their willingness and ability to engage with the media when their issues hit the headlines. g iven the SMC's focus, those joining our database know they are signing up to our goal of improving the way issues are covered by getting stuck into the media debates rather than shouting from the sidelines. Like a dating agency, we pair the right experts with the right journalists when an issue hits the headlines, and at the last count there were over 2000 scientists and engineers signed up to our database.

The quality of our experts is extremely important and many people ask how the SMC selects the experts on our database and how we check for quality and guard against bias. t his is one of the biggest challenges for the Sm C and, given how many experts we deal with, we may make mistakes along the way. However the criteria we use to recruit experts has so far proved extremely effective at ensuring the SMC is putting forward credible experts and good quality science and engineering. t hese criteria include ensuring that scientists are from respected scientific institutes, have a distinguished track record of research and publish in peer reviewed journals. Scientists are generally recommended to us by press officers from universities or scientific institutions as being both media friendly and recognised experts on issues that are likely to hit the headlines. We then set about approaching these scientists to ensure that they fully understand what it means to be on the SmC database. t his involves ensuring that the scientists sympathise with our broad values on the need to engage, and that they understand that the SMC will call on them to drop everything – even late at night or at weekends – to do media work when their area hits the headlines.

Rapid reactions

The demands of the 24-hour media machine mean that news journalists often do not have the luxury of time to track down the best scientists when a science story lands on their desks, which means that availability can sometimes win out over expertise. This is where the SMC steps in. Once alerted to a breaking story, we track down the right experts and, with their permission, offer them to all the national newspapers and news programmes. o ur r apid r eaction service is a real example of a win-win scenario for science and the media: we help frantic news journalists, delighted to be given great scientists to interview, and we enable the best scientists to get their voices heard at the very time that their issues are in the headlines and therefore on the public's mind. Whether it's the latest food scare, an outbreak of foot-and-mouth disease or a controversial medical breakthrough; ensuring scientists engage in the story directly influences what the public see and hear, and in many cases can defuse an unnecessary media scare story. in recent years a 'fact sheet' has been added to this r apid r eaction service after pressure from journalists being asked to deliver fact boxes very quickly for their ever growing online operations.

t ypically, the r apid r eaction service from the SmC will include three things: contact details of leading experts who we have established are both available and willing to do interviews immediately; written quotes from these experts and others who are not in a position to do much media work but can give us their informed reaction; and a fact sheet with a list of accurate, well-established scientific facts about the issue.

Round-Up press releases

t he r ound-u p press release is a similar but distinct part of the SmC service. it ensures that the media have access to scientists and engineers in advance of a story breaking, by offering journalists a variety of comments from experts reacting to embargoed stories that we predict will make the headlines. These generally originate from the major science journals that the SMC has negotiated special advance access to, including *Nature*, *The British Medical Journal* and *The Lancet*. We also have permission to share embargoed papers with trusted contacts to elicit reactive comments, which can then be sent to reporters to feed into their coverage. These comments are often used by journalists to balance coverage and help them to put a 'breakthrough' into a more measured context for their sometimes over-excited news editors (see Nerlich, this volume). We also issue Round-Ups on g overnment white papers, Select Committee reports, and other reports that we are given embargoed access to by our friends throughout the scientific community and beyond. When you see an independent scientist quoted reacting to a breakthrough reported in *The Lancet*, there is a high chance that the Sm C provided that comment. r ound-u ps differ from our r apid r eaction service as scientists have more time to read scientific papers or reports in detail rather than having to react on the spot; these unique press releases provide busy journalists with great sound bites they can use in their articles, while simultaneously informing the broadcast media which scientists are available for interview and how they are reacting.

SMC press briefings

t he Sm C is certainly not restricted to reacting to the headlines, and since opening we have facilitated scientists to generate their own headlines on many occasions. These come from the Centre's regular press briefings – often held when scientists and science press officers feel that good, accurate science is being lost in the public and media debates around certain subjects. These briefings take a variety of forms. Many are 'Background Briefings' introducing the national media's science, health or environment correspondents to the best experts and science on controversial issues like nuclear waste, nanotechnology, stem cell research, animal research etc.

Or they can be 'News Briefings' where we work with scientists to give the national media a new story on developments within science – whether it's an iPCC (Intergovernmental Panel on Climate Change) report, a paper from the journal *Nature* on stem cells or science funding cuts in the Budget report.

The SMC also encourages leading scientists to 'speak out' to the media about policy developments they believe may pose a threat to research – not something science has been renowned for in the past. o ver the years the Sm C has drawn national media attention to scientists' concerns about many issues, including the early drafts of the h uman t issue Bill, the attempts to ban research on human-animal embryos, the moves to repatriate collections of ancient remains being used in research, the deliberate destruction of GM Crop field trials, the EU Clinical t rials Bill and the eu a nimal r esearch Directive.

t he Sm C has established such a good reputation for running professional press briefings, popular with the national media, that many organisations choose to work with the Centre to launch their stories – especially if they have the potential to be controversial and make headline news. Examples include the launch of the Farm Scale e valuation of gm crops, the launch of the r oyal Commission on e nvironmental Pollution's report on nanotechnology, the Committee on Radioactive Waste Management's final report, as well as many of the best science stories published, including *The Lancet*'s publication of the first successful human trachea made from the patient's own stem cells.

'Crap busting'

t he SmC would love to be able to change the media so fundamentally that they never covered terrible science stories, but while that remains an unrealistic prospect at this time we offer the media a specialist and affectionately termed 'crap busting' service. Rather than hectoring journalists for covering stories that their editors tell them to cover, we instead find them leading experts willing to offer quotable comments rubbishing the story that can be included in their copy. r eassuringly, we have countless examples of how these comments often do help specialist journalists to persuade their news editors not to run the story. We also have many more examples of how the comments we have supplied have been used prominently in the articles in a way that provided much needed balance and added a note of scepticism for readers. o ne example amongst others is the reactions we gathered on a press release about how watercress could reduce the risk of cancer, based on a study funded by the Watercress a lliance. t he SmC went to one of the world's leading cancer experts whose measured and informed comments included the fact that to get such an effect we would need to eat so many tons of watercress that we may well turn green. t he story did run in every national newspaper, but with our expert's comments encouraging readers to view it with a very large pinch of scepticism.

Supporting scientists

t he SmC would be nothing without the thousands of scientists and engineers who have agreed to join our ever-growing database of experts. Many of them are new to media work and therefore much of what we do at the Centre involves us providing them with all of the support they need. We produce information leaflets that give advice about when and how to engage with the media, including t op t ips for Media Work, Communicating Uncertainty in a Soundbite and When Animal Research Hits the Headlines. A new leaflet is also being written specifically with engineers in mind, to help them work with journalists on the issues closest to their areas of expertise. We also run our hugely popular introduction to the n ews Media events several times a year, with at least one event each year specifically put together with engineers in mind. Designed to give those who are considering media work an idea of how the UK national news media operate, these events give attendees the opportunity to meet a panel of journalists and discover what the working life of their media counterparts is really like. These sessions always result in lively debate about why experts should engage with the media, and attendees leave feeling much more comfortable about doing so. in addition to these activities, we are always on-hand on a day-to-day basis to answer our experts' queries and concerns, and facilitate their media work during what can often be extremely challenging times.

Philosophy and ethics of the SMC

Is the SMC pro-science?

At the launch of the SMC, Baroness Greenfield emphasised that the SMC would be 'unashamedly pro-science', a phrase that invited criticism from many social scientists and commentators who have welcomed a climate in which science has been subjected to more scrutiny and criticism by the public and the media. It is clear that those involved in establishing the SmC did not feel as comfortable with the growing willingness to distrust and question scientific expertise. For them the loss of trust in science, resulting from sensationalised media rows over BSe, gm and mmr, were bad for science and for society and so the SmC's core remit was identified as helping to renew public trust in science. However, observers of the SmC will testify that the Centre's interpretation of being 'pro-science' is a rather more sophisticated and nuanced one than some critics have given us credit for. Broadly the concept is interpreted as the Centre's commitment to the scientific process, method and an evidence-based approach to the big issues of the day. t he SMC is pro-science, but without being completely uncritical or unquestioning, and it offers up measured, evidence-based criticism on the stories of the day.

As such, the SMC does not take a position on the scientific controversy of the day but facilitates and encourages scientists to enter the fray. it is common for scientists on SmC r ound-u p releases to disagree fundamentally with each other, and we have run media briefings on all sides of contentious debates, such as the efficacy of Alzheimer's drugs, the effects of cannabis on the brain, and the contribution of aviation to climate change.

Choosing our topics

The subjects that the SMC covers are largely dictated by the news agenda. Unlike a traditional press office, the Centre is not trying to generate stories or squeeze our concerns into the news agenda. Instead we make no apology for the fact that the Centre's unique remit means we are primarily led by the science and engineering subjects in the media. If the news is running stories on biofuels, nanotechnology, mobile phones or human cloning, you can guarantee that is what the SmC will be working on at that moment in time.

The press briefings we run are, however, rather less dominated by media headlines and represent instead a proactive attempt to get the scientific community's concerns into the news agenda. Nevertheless, these briefings are always related to topical science controversies that have either been headline news or are likely to become so in the future. t hey come to us through a number of avenues, including scientists themselves, journals, and journalists asking for background on topical issues. it is worth noting at this particular point that, as the Centre's reputation has grown, almost every major scientific institute, University and scientific journal in the UK has used the Centre to run media briefings.

Ensuring balanced reaction

The whole issue of 'balance' in science journalism is a difficult one (see Murcott, this volume). The SMC has argued passionately with editors that the sacred code of journalistic balance is dangerous when it results in news programmes presenting the debates about mmr and climate change, for example, as battles between two halves, when in both cases the balance of scientific opinion is overwhelmingly on one side. I have argued that to reflect the real balance of the scientific debate on climate change, the media should run 99 interviews with mainstream climate change scientists for one with every sceptic.

Similar principles apply to the SmC's own application of balance. Because the Centre is not interested in spinning or managing messages, the views that we project into the media are those held by the scientists and engineers on our database. if all of the eminent engineers and nuclear experts on that database believe that nuclear power should be part of the tool-kit for tackling climate change, then those are the sentiments that will emerge from the Centre. a s a centre which openly reflects the views of mainstream science, we do not see it as our responsibility to scour the country for climate change sceptics or plant scientists who are opposed to gm simply to present a false and distorted sense of being balanced. h owever, when there is a genuine division of opinion within mainstream science, the SmC will reflect this and SMC Round-Up press releases regularly present a series of conflicting views from eminent scientists on a whole range of issues.

Spinning for science

n ot having a brand name, institutional message or corporate identity to promote in the media makes the SMC a radical and unique new experiment in media relations. Writing about PR in his seminal book 'Flat Earth News', Nick Davies (2008: 89) suggests, 'Fabrication is at the heart of PR, the fabrication of news which is designed to open the media door. Pr is clearly inherently unreliable as a source of truth simply because it is designed to serve an interest'. t he fact is that the SmC is a media relations outfit that is interested in what Nick Davies is interested in: improving the quality of science journalism and truth telling. While the Centre works hard to advise scientists on how to get their science and messages across in a way that will guarantee the best quality coverage, it does not attempt to influence those messages. In that sense the Centre's media work is un-spun, a feature often commented on by journalists who find it refreshing to be allowed to question leading experts at the Centre with no restriction. t o maintain that reputation, the

Centre has, on occasion, refused to work with institutions – including Government departments – who have attempted to run briefings off the record or with other restrictions that are in our view not justified. Philosophically we see the Centre as a facilitator, a place where key journalists can meet and question key scientists on their work. This feature is reflected in our decisions not to allow briefings to be chaired by external organisations. instead a panel of scientists or engineers speak about their research, followed by a Q&A session with journalists chaired by a member of the SMC team. The Centre genuinely is a place where journalists can meet scientists and talk openly and honestly without media management or institutional spin.

The other way in which the SMC eschews the kind of controlling spin that Alastair Campbell (former communications advisor to Tony Blair) has made famous in recent years is by never telling the media not to run stories. We see every science story – no matter how contentious – as an opportunity rather than a threat and the Centre is not interested in closing down debates on science. in this sense we are at odds with some scientists who would prefer that recent media frenzies on gm , mmr , and animal research had never happened. t he SmC welcomes the climate in which the media, public and policy makers are more inclined to debate every major new development in science. We embrace these debates as further opportunities for scientists and engineers to have their voices heard and, ultimately, for the public to learn more, not only about the issue at hand, but also about the way that science works.

Challenging the culture of caution: Human cloning

From the earliest days of the SmC, our philosophy of open engagement has placed us in a position of challenge to the scientific community's caution and disdain for the media's framing of certain issues. The first of many such challenges came with a debate amongst leading scientists about how to respond to a series of major front page news stories announcing claims of the first cloned human being. Maverick cloners Panos Zavos and Severino a ntinori and even an a merican religious sect called the r aelians had, over a period of two years, stolen headline news with their un-proven claims that they had produced the first cloned baby. None of these claims had been published in the scientific literature or even announced at scientific conferences. Instead it seemed all these people had done was book a hotel room, invite the media and make their claims. Astonishingly, despite the lack of a shred of evidence in any of these cases, each one made headline news throughout the mainstream media, including the broadsheets and more 'upmarket' publications.

We felt that the publicity for these mavericks was feeding the totally inaccurate view that mainstream science was in a race to clone the first human, and once the SmC was up and running, this was one of the issues that would be very much on our radar. t his misinformation mattered a lot because at the time many stem cell scientists were looking for public support for their attempts to develop their work with therapeutic cloning, through which they could derive patient-specific stem cells vital for research purposes. t he widespread misapprehension that scientists wanted to clone human beings was extremely damaging to these scientists. When the SmC approached the u K's leading fertility and cloning experts, we discovered that there had been a *de facto* boycott of human cloning stories for some time, with scientists so angry at the media's irresponsible reporting of these unsubstantiated claims that they refused to comment on them. it was immediately apparent that the media were once more not hearing from the right experts on the issue. This struck us as being something the SmC had to challenge. While there was an intellectual integrity to the stance that serious scientists should refuse to grace these stories with their presence, this boycott was completely invisible to the u K public who merely saw a series of unchallenged claims that scientists were in a race to clone a human. We went out of our way to kick-start a debate within the scientific community about the need to change our attitude to these stories, and argued the case that what was needed was for the scientific community to speak out every time the media covered these stories to condemn the irresponsible claims and reinforce the message that mainstream science was not engaged in cloning humans. While some continued to insist that we would lack credibility if we condemned the media for running these stories while at the same time feeding these stories with experts and information, the SmC argued that this was exactly what we needed to do. indeed we argued for combining the two – with any experts interviewed using their time and column inches to criticise the media for running these stories with absolutely no evidence.

The first test came early one Saturday morning in 2004 when I turned on the *Today* programme on BBC r adio 4 at 6.30am to discover that the lead story was yet another announcement that the first human clone was to be revealed later that day – yet again by maverick cloner Panos Zavos. With some trepidation I called the leading cloning and fertility experts with whom we had been debating the issue, and by 10.00am i had found six leading experts ready to give up their Saturday to go into television and radio studios to condemn Zavos and emphasise the reality that mainstream science was not interested in cloning human beings. t his strategy paid off with headlines literally changing as the morning went on from 'Doctor implants cloned embryo' to 'Scepticism greets cloning claim' (BBC News 17 January 2004). By mid-day every channel and radio station – all of whom were running the story as headline news – had included an interview with one of the scientists the SmC put forward, and by Sunday every single national newspaper carried a headline and lead paragraph that referred to the scientific community's dismay at the story rather than Zavos' claims. This was our first piece of evidence of how scientists can overcome the culture of caution, and change what the public see and hear by engaging with the story. We now have hundreds of similarly compelling cases of where a story was changed for the better through the willingness of top scientists to engage as and when the debate was happening (SMC presentation on Zavos).

Openness on animal research

For the first few years of the SMC's existence, one of the biggest stories and the greatest single challenges to the SmC's philosophy of openness and engagement was the issue of animal research. This period marked the climax of the animal rights extremists' attempts to put an end to animal research through a campaign of intimidation and terror. The SMC was called upon by the scientific community to react to a seemingly non-stop succession of stories caused by these extremists. t he u niversity of Cambridge's decision not to build a new animal house after threats and intimidation; t he u niversity of o xford's announcement of a halt in the building of their new facility for the same reason; the theft of the dead body of a member of the family running a breeding centre for animals for research; that centre's subsequent announcement that they were to cease trading; continuous attacks on ordinary working people who were in any way connected with h untingdon l ife Sciences; and so on. All of these stories became headline news and the SMC worked with groups like the Research Defence Society (RDS) to react to each and every one of them.

During this time, three things became clear: firstly, that the number of scientists the SMC could call on to do media work when these stories broke was miniscule, with brave souls like Colin Blakemore, Robert Winston, Chris Higgins, Nancy Rothwell, Tipu Aziz, John Stein, Roger Lemon and a handful of others taking on the burden of defending animal research almost entirely alone in the scientific community. In addition, while many press officers stood shoulder to shoulder with the SmC on most controversial issues, many were either reluctant themselves to push scientists to speak on this issue or restrained in doing so by their institutions and university authorities. t hirdly, the climate created by extremists meant that many positive opportunities for scientists to speak out on developments in animal research were being lost.

Tackling all three of these problems became a major priority for the SMC team and, working with like-minded scientists and press officers at the Medical Research Council (MRC), Wellcome Trust and some universities, we developed a number of initiatives to challenge the climate of fear, increase the number of experts available and encourage more pro-active media work. These included a series of novel events called 'Speaking out on Animal Research in the Media' in which scientists who were reluctant to speak out were addressed at a half day seminar by those scientists who had spoken out, by the police unit set up by Government to deal with animal rights extremism, by r DS staff with years of experience of supporting scientists who speak out, by trusted science reporters who could show how to deal with this issue responsibly, and by press officers making the case for more openness and transparency on the issue as a protection against negative headlines. t hese events, which r DS have emulated and continued to run, were a huge success, and within two years the number of scientists willing to speak out on this issue rose from ten to over a hundred. Similar events were also organised specifically for press officers when they were inspired by other colleagues to fight harder within their institutions for a more open policy on speaking out.

Finally, and very importantly, the SMC argued that the scientific community should identify more opportunities to change the balance from reacting to extremists' attacks to being proactive about the need for animal research. One example of this was the annual Home Office report publishing the statistics on the number of research procedures involving animals carried out. We were aware that the scientific community would need to be ready with a response every year the report was published on the Home Office website, from where it was promptly taken by animal rights campaigners who ensured that their favourite journalists received the story with their spin on it. This immediately struck us as a lost opportunity for the scientific community, once again forced into reactive mode even when it was their own story. We proposed an annual media briefing at the SMC where the Home Office inspector would reveal the figures alongside leading scientists who could explain any increases in relation to scientific developments – so the increase in gm animals could be explained by the explosion in genomic medicine in the wake of the mapping of the human genome, and the tiny increase in primates one year was explained by developments in monoclonal antibodies, including drugs like herceptin and avastin that the public were demanding access to. t he SmC is proud to say that we succeeded in adopting this new approach and the format has indeed become an annual event. o ther, similar achievements on openness came with briefings on new ways to measure animal suffering and the need for better regulation of animal research.

t his is one of many issues where there has been radical change in the culture of science since the Centre opened. t he SmC now has access to hundreds of scientists prepared to speak out on animal research, most universities and institutions have statements of support on their websites, and the heads of funding agencies like the Wellcome t rust and mr C actively encourage their researchers to become more open. The new atmosphere was confirmed by the announcement of the opening of the new Biomedical Sciences building at the u niversity of o xford. n ot only did the university come to the SmC to announce the opening to the entire national news media, they also invited the BBC to film inside one of their labs for the main television news.

n evertheless, there is still a long way to go before we have the openness needed, and it is still the case that even the most trusted journalists struggle to gain access to animal research facilities, and some senior science press officers still take a cautionary and secretive approach no longer justified by the currently diminished threat from extremists.

Science in the media: Turning the tide?

Giving science its place in the sun

h opefully it is clear that the SmC's philosophy and approach to science in the media define the way that we operate. Seeing science in the headlines as an opportunity rather than a threat, believing that engaging can change the story, encouraging openness and discouraging spin all influence the style and atmosphere at the Centre. t here is another feature of the SmC that i believe has improved not only media coverage but also the scientific community's experience of engagement, and that is our attempt to give science its place in the sun. in the very early days the SmC used to approach 'pro-science' spokespeople outside of science to do media work – and a glance at our early press releases will reveal patients, politicians and even Bishops in our round-ups. t his practice changed very early on when we realised that the problem we were to set up to solve was precisely the ease with which journalists could access patients, campaigners and clerics, in contrast to research scientists. Added to this we discovered that if policy makers, politicians or patient campaigners sat on panels at our briefings, the whole tone of the briefings changed away from science and towards 'messages' and 'policy'.

From an early stage, and with the guidance and support of our Board of a dvisors, it became a characteristic of the Centre that we would focus primarily on scientists and engineers, and consciously attempt to ensure that research science gets a much higher profile in the controversies of the day. It is now very, very rare to ever meet a politician, patient or campaign group at the SMC, and we take great pride in the fact that, when journalists attend SMC briefings, they get much more than a science story – they get a small lesson in the way science operates and develop an ever greater understanding of and sympathy with the experts carrying out the research themselves.

News versus specialists

It is well known within science circles that science news is covered more accurately when covered by specialist science, health or environment reporters, rather than general news reporters or political editors. a cademic studies of the media's coverage of gm and mmr have shown that accuracy and truth are often the first victims when the stories move from the specialist science pages to the front pages. However, one of the most positive developments in the past five years is that this trend has been reversed, and it is now almost certain that any major breaking science, health or environment story will stay with the specialists. Interestingly the Human Fertilisation and Embryology (HFE) Bill, which provoked huge controversy by permitting research on human-animal admixed embryos, was covered almost exclusively by science reporters, even when it was debated in the Commons and became the subject of a political row. The work of the SMC and other science press offices, and the support we give to specialist correspondents, has undoubtedly helped to strengthen their hand by ensuring that they get the best science stories in advance of non-specialists in the news room. t he SmC has continued to champion specialist reporters both within the scientific community and in all our dealings with news editors. it is our strong view that they are the best allies of science in the media, and that we lose them at our peril.

An example to aspire to: The battle for human-animal embryos

a s discussed in this chapter, the SmC was built on the foundations of stories widely perceived to have gone badly wrong for science. ‘What Went Wrong’ with the media coverage of the BSe crisis, gm crops and the combined mmr vaccine has driven the work of the SMC and inspired us to support scientists in becoming more effective at engaging with the big controversial stories that hit the headlines. a nd now the SmC has a story of ‘What Went r ight’. t he battle for human-animal admixed embryo research that raged in the media from 2006–2009 has finally provided the Centre with a model of how scientists *should* engage with the media. A more detailed account of the scientific community’s efforts to overcome the ban on human-animal embryos has just been published.[2] h owever, it is worth highlighting that many of the approaches that the SmC has pioneered were applied to the media work around this contentious issue.

It is a little known fact that leading stem cell scientists were the first to kick off the media debate about human-animal embryo research when they briefed science reporters at the SmC in June 2005. Stephen m inger, r obin l ovell-Badge and the late Anne McLaren did what all scientists should do: they took one of the most controversial areas in their field and gave journalists an in-depth briefing on the scientific potential as well as the ethical issues around this research; even voicing their concerns about a gaping regulatory loophole.

Having generated the first UK headlines on human-animal embryos, this was followed up by a series of SMC press briefings as scientists moved towards applying for licenses to use animal eggs in their therapeutic cloning work. Then, when the subject became the most hotly debated aspect of the UK Government’s h Fe Bill, these scientists again made themselves easily accessible to science and health journalists from the tabloids, broadsheets, radio and television news.

a long the way, the scientists involved had to cope with some scary headlines, with graphics depicting giant mutant rabbits and cow heads on human bodies, but their bravery in tackling these controversies in the full glare of the national news was rewarded by largely excellent coverage. h eadlines such as ‘e mbryology Bill: Bishop’s ‘Frankenstein’ attack smacks of ignorance’ (*Times*, 24 March 2008) also show how the ‘monster metaphor’ in media discussions of science has developed. o nce so pervasive in debates surrounding cloning, assisted reproduction, gm and other controversial areas of science, the metaphor of science as an unholy creation out of control is starting to be replaced with one in which the monster represents the misunderstanding or misrepresentation of science, which the scientists themselves step forward to correct. t his is a prime example of the monster for once being tamed.

m ore importantly, by the time the Department of h ealth indicated their desire to ban this research in December 2006, in the early drafts of the g overnment’s

2 See a cademy of m edical Sciences et al., 2009; for an analysis of the u K newspaper coverage of this issue, see Williams et al., 2009.

planned fertility laws, the health and science reporters on every national news outlet already understood the basic science involved and could explain why the experts wanted to pursue it. They also trusted and respected the key scientists. t he accurate and well-informed media coverage of one of the most controversial issues of our time was evident throughout this debate's twists and turns. in m ay 2008, our elected representatives reflected public opinion by voting in favour of allowing the research to continue, and in n ovember later that year the bill received r oyal a ssent and became the h Fe a ct.

h ere, on show, was the exact opposite of the national gm debate – policymakers and the public came to an informed decision on a controversial new area of scientific research following a major national debate in which the voice of research scientists was heard loud and clear. a nother issue worth noting is the huge support given to stem cell scientists by all of the u K's leading medical research and scientific bodies. None stayed silent or ran in the opposite direction, as has previously happened with issues like GM and animal research. Instead the Wellcome t rust, the m edical r esearch Council, the a cademy of m edical Sciences and the Royal Society all backed this controversial research in the boldest and most public way, and the Association of Medical Research Charities (AMRC) and the g enetic interest g roup brilliantly galvanised over 200 patient and medical research charities to back the bill.

More than anything else, this is a story of top scientific researchers taking the decision somewhere along the line that engaging with public concerns is a key part of their roles as scientists. in doing so, they made history and changed the narrative of science and the media from a negative one to one that is both positive and inspiring.

Conclusions

For six years the SMC has been doing the most risky of all things – putting scientists at the eye of the media storm on some of the most controversial science stories of our times. By rights the Sm C should by now have amassed hundreds of horror stories of sensationalised articles, and scientists so badly distorted that they will never do media again. in fact we have the opposite; we have thousands of examples of controversial science and engineering stories covered accurately and responsibly because some of the best experts in the world worked with some of the best journalists in the world to create something we should all be proud of. There are many problems left to solve and the fast rate of scientific change combined with developments in the media, and new media, present novel challenges almost daily. However, we are confident that the SMC's approach is and will continue to be fit for purpose.

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Part III
Science Communication, Metaphors and Practical Realities

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Chapter 8
Genes, Genomes and What to Make of Them

Jon t urney

Introduction

l anguage, thought and metaphor are inextricably mixed, as several chapters of this volume attest. So any discussion of what might be good or bad, desirable or undesirable, about particular metaphors must proceed carefully. a s a minimum, any commentator should pause and consider why a particular metaphor is being deployed, what effect it might have (and whether there is any evidence for this), and what alternatives there might be.

in genetics, this leads into a real tangle. t here are powerful and indispensable theory constitutive metaphors which have shaped the history of molecular biology. There are a further set, often used alongside the first, in efforts at elucidation, explanation, translation or appropriation of new theories, concepts or ideas. a nd there are the framing metaphors common in science journalism, which may appear in conjunction with any or all of the above.

Further complications arise because there is no clean separation between these types, though they may still be analytically useful. a s in other areas, metaphors deployed for theory development carry other connotations – language is like that. Sometimes, the unintended effects this may have do not matter much outside the science concerned. The fact that 'superstrings', for example, sound like something which might be understandable – unlike most of contemporary physical theory in its mathematical aspects – may have given one candidate for unifying relativity and quantum mechanics a public relations advantage over others which are less easy to label so neatly. However irksome this fact has been for some theorists, its effects in the wider world seem modest.

Biology-related metaphors are different, perhaps. Some aspects of biology, at least, can be more immediately consequential than theories about the foundations of physics. a nd the fact that biology is steeped in metaphor has attracted much critical attention, though in ways largely ignored by practitioners. t his applies to evolution (including the core metaphor of natural 'selection'), and immunology (with its wars, surveillance, and controls at the border) as well as genetics.

g enetics, however, has probably generated the largest literature examining the metaphors in play. This extends to book-length studies (Nelkin and Lindee, 1996; and Condit 1999b; van Dijk 1998), and has generated some illuminating disputes. When Dorothy Nelkin and Susan Lindee reported the prevalence of metaphors indicating that genes are all-powerful determinants of the outcomes of growth and development, for example, Celeste Condit suggested that this neglects the diverse ways in which such metaphors – specifically the idea of the ‘blueprint’ – are actually interpreted by readers (Condit, 1999a).

In addition, looking outside academe, popular authors are unusually conscious of the role of metaphors in communication around genetics. Richard Dawkins, for example, has commented frequently on the appositeness, or otherwise, of genetic metaphors – while also, on occasion, denying that the particular usages he favours are metaphors. a uthor of some of the most famous metaphors in biology, ‘the selfish gene’ (Dawkins 1976), ‘the blind watchmaker’ and ‘climbing mount improbable’ (Dawkins 1986, 1996), he is acutely aware of the risks and benefits of metaphor use in the popularisation of science. a s he wrote in the preface to the second edition of *The Selfish Gene* in 1989, ‘e xpounding ideas that have hitherto appeared only in the technical literature is a difficult art. It requires insightful new twists of language and revealing metaphors. i f you push novelty of language and metaphor far enough, you can end up with a new way of seeing. a nd a new way of seeing, as I’ve just argued, can in its own right make an original contribution to science.’ Robert Pollack (1993) has also reflected at book length on whether the metaphor of DNA as a text invites the equivalent of literary criticism. In addition, Stephen Rose has often used metaphorical critique as part of his general opposition to reductionism, most notably in *Lifelines* (Rose 1997).

In my observation, all of this has had some effect on journalism. How much of an effect is open to question, but this chapter will not offer data on that interesting issue. Instead, I want to look at the problem of writing about genetics in the press – or for online news – from a slightly different point of view. Journalists, who pay reasonably close attention to what is happening in the science of genetics, are also aware that ideas about genes, genomes and gene action are changing. t his is part of the reason why some journalism about genetics has become more cautious. However, I would suggest that taking account of those changes within the confines of news writing presents interesting difficulties.

t he changing meaning of ‘gene’ and its metaphorical framing

Despite occasional calls, more in hope than expectation, to consider eschewing use of the term ‘gene’ altogether (Keller 2000), as far as I know, no-one is really claiming that we are headed for a post-genetic biology. Still, the idea that a ‘post-*genomic*’ biology is taking shape is certainly being widely discussed and the role of genes in this new era seems to be changing for biologists.

h owever, this does little to account for the history of the gene concept, since much of the detail feeding into new pictures of how genetic information is arranged and used predates both the human genome project and those in other organisms. For instance, although the notion of alternative splicing, in which an rna transcript is processed to produce several different gene products, was first used to account for results obtained in viruses in 1977, it is now regarded as the rule, rather than the exception. it is now typically used to illustrate summary accounts which show how ideas about genes are changing radically, or at least are in flux. One such account would be the wide-ranging news feature from *Nature* in 2006, which argued that there is a perplexing question confronting biologists: What is a Gene? (Pearson 2006).

t he message of such accounts is that genes are not what they used to be. a lthough, as already indicated, whether they ever were, and indeed how the gene concept can be understood, are matters of longer-standing debate.[1]

One – still simplified – version of the recent history of the gene runs as follows. The effort to map and sequence entire genomes has been a brilliant success, but, like many scientific successes, it has created a host of interesting new problems. Furthermore, in the case of the Human Genome Project there is a larger irony: the fruits of post-genomic biology are awaited by an expectant public but their expectations, and some of the attendant fears, may be based on a notion of genes and gene action which will not survive much longer in the new genomic world.

Some of the impetus for changing the notion of the gene has come from scientists themselves. a s n erlich and colleagues note, Craig Venter – famous as one of the leading lights of the genome programme – has challenged the prevalent metaphors for the genome (Nerlich and Hellsten 2004), while Richard Dawkins, of whom more below, has written similarly about the misleading implications of 'genes for' (Dawkins 2000). And, as Nerlich also notes, such contributions have had little effect on the language of media reports about genome science (see also Turney 2005).

What is harder to judge is whether, and how, this situation might change as the science develops further. t he current position in professional writing and discussion is that while it is unlikely that anyone is going to give up the term gene anytime soon, the fact that it means different things to different people at different times is becoming clearer. One project which demonstrated this convincingly was the survey carried out by philosophers of science Paul Griffiths and Karola Stotz which looked at how biologists in different research areas differ in their use of the term (Stotz and Griffiths 2004a, b).

t he differences arise in part from some of the new complexities now becoming better appreciated, particularly in the ways in which active gene sequences are, as it were, composed for the occasion. As Griffiths and Stotz put it in a seminar, 't here are an awful lot of extremely complicated ways to be a gene'.

To describe the details of just one of the examples used in their project, consider a DNA sequence transcribed into a pre-messenger RNA. The RNA contains four exons, or coding sequences. In this case, there are two different ways they get spliced together to make a working messenger RNA. As depicted in the diagram (Figure 8.1), in the first, exons 1, 3 and 4 are united. The other has exons 2, 3 and 4. But there is a further complication at the next stage in the process. t he two spliced

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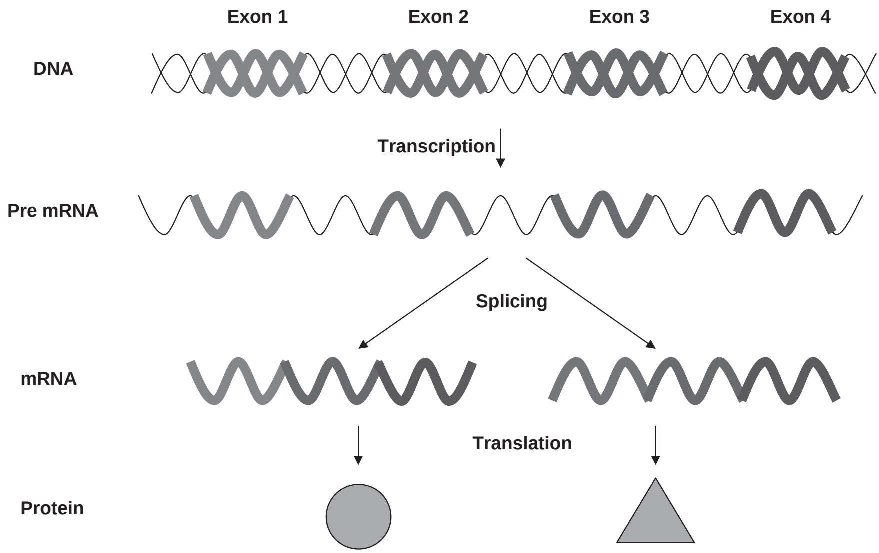
1 t he history and the philosophical issues are usefully summarised, with an extensive bibliography, at http://plato.stanford.edu/entries/gene/.



f igure 8.1 t ranscription of DNa into pre-messenger RNa

messengers are assembled so that exons 3 and 4 are read differently by the protein building machinery – technically in a different 'reading frame', depending on whether they end up joined to exon 1 or exon 2. This means that the two eventual protein products have very few amino acids in common.

Does this mean that we have one gene here or two? h ow do biologists decide? The responses to these and many other problems of annotating DNA sequences already appear to indicate, for example, that developmental and evolutionary biologists tend to conceptualise genes in different ways. in addition, as the meanings of 'gene' shift in the professional literature in response to these novel findings, those of other associated words are becoming less stable, too. Griffiths and Stotz (2006) report that, 'In early 2005 our Google search for definitions of "exon" yielded twenty-six examples, of which sixteen restricted exons to coding sequences, five permitted them in untranslated regions of the gene (UTRs) and five were unclear on the point'.

So it is becoming difficult to keep track of how biologists are conceptualising genes in the twenty-first century. Yet more difficult, I suggest, is the task of communicating effectively about these new properties and configurations of genes to different publics. u nsurprisingly, after a century of the gene, these complexities have been slow to make an impression on the popular media. The old metaphors for genes and genomes, whether they originate in scientific discourse or in popularisation or the rhetoric of research promotion, are familiar. We read of the map, the code, the Book of Life, the blueprint, the recipe, the master molecule, and we often get the message that Dna is destiny.

a s already noted, although it is rightly pointed out that such renderings of the gene are misleading (Weigmann 2004), surveys indicate that they continue to dominate journalistic writing about genetic discoveries and their implications. Some have questioned how much this matters. As mentioned above, studies of readers suggest that they interpret the blueprint metaphor, for example, less deterministically than is often supposed (Condit 1999a). However, there does appear to be an emerging mismatch between the image of the gene in the public realm and recent scientific understanding. If it is desirable to have informed public debate about new genetics and its applications, it would be helpful to start work on improving the alignment of these images.

But how might one achieve this? h ow can language and indeed metaphor start to reflect this more fragmented, complex and context-dependent view of genes, which focuses no longer on what genes are but rather asks what they do within a biological system that changes and develops over time? it is still often a struggle to find words to summarise what we now think we know. The philosophers occasionally have a go. h ans-Jörg r heinberger, for example, suggests that 'there is a whole battery of mechanisms and entities constituting what could be called hereditary respiration, or breathing' (Rheinberger 2000). This, though, while charmingly poetic, is not really concrete enough as an aid to understanding. m ore often, those who approach the topic from a conceptually rigorous point of view use more austere language. Thus, while Giffiths and Stotz (2006) write, playfully, that genes are 'things an organism can do with its genome', they go on to say that 'they are ways in which cells utilise available template resources to create biomolecules that are needed in a specific place at a specific time'. The emphasis on *ways* (plural) is unpacked in the following terms:

> the gene has become a flexible entity with borders that are defined by a combination of spatial organisation and location, the ability to respond specifically to a particular set of cellular signals, and the relationship between expression patterns and the final phenotypic effect.

t his is their conception of a '*postgenomic* molecular gene', which emerges from the effort to understand how gene function is tied up with the structure of the genome, and reduces emphasis on the gene as a fixed unit. It reinforces the view that the end result of a set of genes – the phenotype – is not any straightforward expression of genetic information, but is produced through the action of a 'developmental system,' which includes aspects of the environment. a gain, this view is not new, but takes on a new salience in the post-genomic era.

t he overall situation now, according to Stotz, who elaborates on these ideas in a way which is worth quoting at length, is that

> we have to revise most if not all our expectations of genes and their capacities. For the largest part of the last century we came to see genes as a material unit with structural stability and identity, with functional specificity and template capacities

> that encodes information, with intergenerational memory, the designator of life, and the site of agency and even mentality (in containing a plan or program for and asserting control over developmental processes). In the postgenomic era, however, there is no DNA sequence that exhibits any or all of these traits without the help of an extensive and complex developmental machinery. t he phenotype at the narrowest molecular level, under certain readings the genotype itself, and the information it contains, is constituted by epigenetic processes. instead of a linear flow of information from the DNA sequence to its product information is created by and distributed throughout the whole developmental system. (Stotz 2006)

in this view genes no longer determine 'things'. instead, other 'things' determine what genes do. What was once relatively fixed is now decidedly flexible.

Writing about genes and genomes

t his is all well and good. t he history and philosophy of genetics is a fascinating study for those with a taste for it, and the current debates in biology are also intensely interesting. However, it seems to me that detailed knowledge of either, or even both, does not make the job of a news writer any easier.

Let us look at the task of writing about a new finding in genetics from the point of view of a journalist, pushed for time and with limited space. Such constraints encourage pragmatism. What the journalist needs is not so much detailed appreciation of issues in history or philosophy of science, or even connoisseurship of the science– rewarding as these may be to develop, and even useful in their way. Rather, he or she requires ways of framing, metaphors, figures and tropes – call them linguistic resources – which will help get the story written clearly and expeditiously. if the resources available are poor, one or two inspired individuals may, every now and then, be able to create new ones. m ost of the time, however, the old ones will be raided for lack of an alternative.

in the case of the post-genomic gene, the main problems, i suggest, arise from a requirement which is at the heart of science writing, and which has always been tricky to solve for genes. It is a problem of explanation. As with other scientific explanations, providing an account of gene action demands what o gborn and colleagues in their breakdown of explanation call 'creating entities' (Ogborn 1996). That is, there needs to be a way of describing what genes are, what kind of thing, what they can do and what their capacities, properties and potentials might be. Furthermore, all this needs to relate to something which does what it does in a realm remote from everyday experience and action. a s o gborn *et al.* put it, 'an explanation of the mechanism of heredity involves novel actions of novel entities… The story involves unfamiliar objects which do unfamiliar things in an inaccessible world' (1996: 10).

t hese invisible entities do, we believe, have effects which are visible but there is an additional challenge in explaining how the various entities at different scales between genes and organisms – cells, tissues, organs and systems – interact. if the effects involve human behaviour, then mind and brain are implicated, too.

a s we have seen, in both these areas for explanation, the linguistic resources which derive directly from scientific research communities are a mixed blessing, and have been for some time. So, a journalist reading around the subject might ask: what else is there which might help convey the interactivity, fluidity, and dynamics of genomic systems? t he domains that metaphors might be drawn from are limited. There are only so many different ways of thinking about a complex situation, so many things which a living system might be *like*. Potentially useful suggestions so far come from musical, ecological, and social domains (see Porta 2003; Pappas 2005; n oble 2006; o uzounis and m azière 2006; Knudsen 2005; Lopez 2007).

t he musical variations still tend to be tied to information. t he Dna becomes a musical score instead of a linguistic text, and it can be interpreted or govern an orchestration. But it is not otherwise an interactive or dynamic image. Sometimes, the orchestration extends to a 'work' which includes several different kinds of information, reducing the priority of genes. Denis n oble, physiologist and long-time advocate of systems biology, has developed this view at book length in his recent volume *The Music of Life* (2006). The book takes issue with genetic determinism and reductionism and uses Richard Dawkins' gene-centred view – or, rather, others' interpretations of that view – as its main metaphorical foil. n oble advocates a systems biology approach, which he elaborates as follows:

> Systems biology [..] is about putting together rather than taking apart, integration rather than reduction. It requires that we develop ways of thinking about integration that are as rigorous as our reductionist programmes, but different […]. it means changing our philosophy, in the full sense of the term. (Noble 2006: 21)

To change this philosophy he advocates replacing 'the book of life' metaphor with the 'the music of life' and to lead scientists away from single genes to whole systems and interactions between elements of the system – think of gene organism interaction as polyphonic music

John Avise (2001), reflecting on the increasingly complex roles of transposable genetic elements in genomic evolution and regulation, has advocated both the social and ecological pictures. Perhaps one can see the genome as a commune, he suggests, a tightly bound organisation with an intricate division of labour. o r it might be helpful, harking back to an image first used by Lewis Thomas in the 1970s to depict the cell (Thomas 1976), to liken the genome to an ecosystem, in which different genes fill different niches.

o ther possibilities again draw on the growth of systems biology, and focus on the properties of networks. Some are relatively simple. A road network, for instance, is interconnected in ways which offer lots of different routes from a to B. An individual gene might then be like a single road. Block it, and the traffic may still get through, though by a more circuitous path. (McFadden 2004).

One of the most striking images so far comes from a philosopher, Lenny m oss, and is a more developed version of a vise's communal metaphor. a t the end of his subtle and complex account of genes and gene action, he considers two stages of gene expression which are regulated by impressively large assemblies of molecules in complex organisms. First is transcription, in which the precise selection of exons for an rna transcript depends on the presence or absence of a variety of transcription factors which interact with the Dna strand and with the enzyme rna polymerase. t he second is post-transcription splicing, which is the task of the spliceosome, an intricate array of five small nuclear RNAs and perhaps as many as 150 separate proteins.

The scientific account of these operations has obviously been built up by painstaking work over decades, and their sensitivity and exquisite modulation is still hard to grasp. Popular articles about the spliceosome to date largely eschew memorable metaphors (Ast 2005). Moss, though, offers one in terms of decision-making. The decisions taken to produce the final configuration of the mRNA on the path from Dna to protein are in the hands of 'ad hoc committees'.

He likens each committee to a constituent assembly. The more members join, the more information they can supply about recent events in the cell, and interactions with other cells. t he committee is a way of pooling experience which leads to a kind of consensus about next steps. This strikingly anthropomorphic metaphor certainly gets away from simple genetic determinism. it describes an operation which is dynamic, flexible, and which can use information accessible to any of the individual parts.

t he picture this offers, however, is still somewhat abstract. it still seems to imply that there is some central agency – even if it only convenes for each momentary review of the situation – which somehow 'makes up its mind'. It is still, perhaps, hard to grasp what this picture of gene action is trying to tell us about the developmental system described by Griffiths and Stotz.

t hat suggests a metaphor with a more physical feel might be helpful. a typically thoughtful and cleverly-worked-out suggestion from Richard Dawkins, perhaps the most famous gene metaphor specialist, is given below. in a newspaper article explaining why simple, deterministic ideas about genes are erroneous, he presents an analogy which is worth quoting at length (Dawkins 2000; see also Dawkins 2003):

> 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.
>
> t he 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. t he 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 fter this lengthy elaboration, he summarises the moral, that there are not 'genes for' this or that trait:

> 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.

This is a finely wrought and memorable image and it strikes one as a good analogy, which can be visualised in a way which others cannot, and gives a real impression of the interconnectedness, and lack of simple path causality which is one of the main things to grasp about the genome. it is, however, more suited to re-use in a book than a newspaper article.

Developing new ways of reporting on genes and genetics

Taking stock, the examples cited above suggest that there are resources to draw on for describing gene action in the post-genomic era. However, I think it is fair to say that none quite lends itself to the degree of compression required in a news report. The consequence, for now, seems to be a continuing lack or lag. Journalists sensitive to the limitations of previous standard forms – notably 'genes for' – for conveying the implications of new scientific findings try and avoid using them altogether. in short pieces, there is as yet no really satisfactory substitute. t his occasionally gives rise to the urge to write longer articles in an attempt to clarify the current situation. But these still do not really refine the metaphors in ways which lend themselves readily to re-use elsewhere. a gain, i have no systematic data on this, and must content myself with a few concluding examples to provide a minimum of support for these conclusions.

r eports about the origins of autism furnish good examples of the style of current news writing about genetics because the condition has a high profile, multiple loci have been implicated, and it poses all the problems of understanding exactly how information encoded in Dna may affect things at the level of the mind/brain. One recent (2005) finding was reported in the *Times*, for instance, in terms which successfully dispense with a 'gene for'. u nder the headline, 'Discovery of faulty gene offers hope on autism', Mark Henderson wrote that, 'A single gene that appears to increase the risk of a person developing autism when mutated has been identified by scientists, suggesting new approaches to diagnosing and treating the condition.' That is quite long, as leading news sentences go, and effectively sidesteps any suggestion of direct cause, at the cost of something which has to be phrased in a rather cumbersome way, 'gene that appears to increase the risk of a person developing…'. (*The Times* July 26, 2005) This at once implies that the appearance might be deceptive, that the risk exists in any case and is only increased, and that some developmental process ensues in those affected by the mutation.

A later report (concerning a different gene) uses a different strategy, to similar effect. a ccording to a r euters' health correspondent, 'a gene that helps the brain make connections may underlie a significant number of autism cases' (Fox 2008). a gain, this neatly compressed formulation implies that the gene is only a part of the preconditions necessary for making the connections in question. The gene – or presumably its altered form – only underlies autism, rather than causing it directly, and then only in some cases, so others will involve different underlying predispositions. t he elaboration which follows is also instructive. t he writer goes on:

> Disruptions in the gene, called contactin 4, stop the gene from working properly and appear to stop the brain from making proper networks…
>
> t hese disruptions, in which the child has either three copies of the gene or just one copy when two copies is normal, could account for up to 2.5 percent of autism cases.

a t this point, the story becomes noticeably harder to follow. We are entitled to wonder what might count as 'working properly', why having one too many – or one too few – copies of the gene might disrupt this proper working, and who thinks 2.5 per cent is significant in this context. The last of these queries is answered (the researchers say it is significant). The others are left hanging.

Such problems aside, these stories suggest that one aspect of gene action, which is becoming clearer in post-genomic biology, can also be reflected in news writing. e ssentially this is the tendency to move away from 'genes for' and toward complexity. As Peter Conrad (2001) has argued, the 'one gene, one disease' (OGOD) model acquired common currency partly because it fitted onto the established template of one germ, one disease. h owever, in genetics, this model now confronts more exceptions than cases which fit the rule. Most of the conditions investigated prove to be affected by many different genes, or perhaps turn out to be a whole collection of different conditions with related symptoms, which may be a different way of saying the same thing. m any genes turn out to affect a large collection of traits, and come with different outcomes according to circumstance.

This, it seems, can be accommodated within the confines of a news story, albeit at the cost of some circumlocution. h owever, it would be wrong to suggest this is now the prevalent approach. Perform a g oogle search for 'gene causes', and you will still score more than a million hits, some of them headlines from recent news stories, many of them the titles of journal articles. However, phrases such as those quoted about autism, along with 'gene risk', 'gene link with', 'gene associated with', 'gene implicated in', or even 'affected by', are now also a common feature of genetics stories, even in headlines. Aside from this less definite language, the other cost of an honest effort to reflect complexity, from the journalist's point of view, is that it may lead to a point where there is hardly a story at all.

h owever, the other aspect of complexity, which leads to doubts about what a gene actually is, and a collection of entities which may count as a gene under different circumstances, is not reflected in these stories. It is not hard to believe that trying to do that as well in the same story would simply lead to the writing collapsing under the weight of its caveats and acknowledgment of possible contrary instances to the central chain of cause and effect behind the story. imagine, by the time you have written, 'a gene, a variant form of which may, in certain circumstances, be associated with an enhanced risk of developing (condition X) – although it must be admitted that, just now, no-one is quite sure exactly what a gene is…' you may well have lost your reader, even if your news editor defers to your scientific expertise, lets you compose the story, and can then bear to print it.

Can this be overcome in a journalistic context if the writer has more time and space to work in? Up to a point. For an example of the longer, feature-style treatment, i choose a piece from the *New York Times* by biology specialist Carl Zimmer (2008).

it covers many of the points already made in this chapter, and is replete with metaphors. h owever, none of them really applies directly to gene action. t he reader learns that new studies mean that the gene 'is in an identity crisis'. t he story of genes, Dna , rna and protein has to be revised because many 'complications' have emerged, as scientists 'wade into that genomic jungle'. In fact, the genome is 'full of genes that are deeply weird'. Epigenetics, the chemical marking of DNA, means that 'heredity can flow through a second channel'. And the cluster of proteins which add methyl groups as markers at particular points on the DNA are led there by a specific RNA molecule which acts as a 'guide'. Other passages refer to 'genomic baggage', 'dead' pseudogenes (and some which are 'undead'!), and even bits of the genome which are 'the rotting carcasses' of viruses, though as these can 'jump around' presumably they also number among the undead.

a ll of this is leading to a paradigm shift in how genes and genomes are conceived, or perhaps, in the words of one of the scientists quoted, an older kind of shift, crossing the Rubicon and pausing to look back and realising that the protein-centric view of gene coding is 'quite primitive'.

The piece is skilfully put together, covers a lot of ground in 3,000 words, and through all this metaphoric richness adds colour to a picture of biology in transition. Yet we are left with no clear impression of where this transition will lead. t his may well be a fair reflection of the state of the science. But it sits alongside a continuing stream of news stories that link a gene or genes – however defined – with some medical or behavioural trait of interest. t he tension between these two media portrayals of genes may be sustainable for quite a while. In fact, it will probably persist until there are some convincing new off-the-shelf metaphors for what genes do and how they do it, which can be woven into a news story without a long list of caveats about how they really need further qualification of explanation. i wonder what they will be?

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Chapter 9

A Workbench View of Science Communication and metaphor

t im r adford[1]

If there's one thing a news desk likes more than a breakthrough, it's a revolutionary breakthrough. One tries never to use such a phrase, but it pops up all the same: science reporters may vow each morning chastely to avoid all occasions of semantic sin, but the mainstream media commentators who amplify their reports are not always so finicky.

It would be wrong, however, to imagine that science writers always think very carefully about the metaphors they use, or that they worry far into the night about accusations of hyperbole. In the press of journalism – that is, in the jostling and sometimes over-excited stampede to claim access to the space and time available to serious news in newspapers and broadcasting – subtle and complex ideas tend to get trampled or flattened, metaphors get mixed and journalists get carried away.

This is because – for most of the working year – there are more stories competing for limited space and air time than the media can accommodate, and a fair proportion of these stories fall into the category of news that readers might reasonably expect to read or hope to hear. t hat is, people open a daily paper or tune in to a preferred news bulletin to find out what the government has decided about interest rates, which group has launched a peace mission to the middle east, which players might be selected for the semi-final, and what Britney Spears wore last night. If they don't find what they hope to find, they buy another paper or turn to another channel. So the news list that is read out at the editorial conference each morning opens, almost invariably, with items that news editors find predictable and therefore rather boring, but non-negotiable. t hat limits the space for stories that people do not even know that they want to know – that is, to put it more sharply, real news.

l et us try a little test. a science correspondent goes to his news editor and says, 'I have this very interesting report about a significant advance in the understanding of the development of small cell cancer, at least in laboratory mice. it is not a breakthrough. It is to put it at its strongest, an incremental advance in a very useful line of research that may one day illuminate the understanding of a biochemical pathway that leads to tumour formation. It is unlikely to result in a cure for cancer

1 t im r adford was, until 2005, science editor of *The Guardian*. h e had also previously been its arts editor and its literary editor. He is now a freelance journalist.

of any kind in the immediate future, or perhaps even in the long run. It does however throw interesting and instructive light on the process of science, in my humble opinion.’ h alf a second later, a sports reporter stumbles breathlessly to the same spot and says ‘t he captain of the e ngland team has been found off his face on class-A substances, in a bed with two tarts and a junior minister’.

Here is examination question number one: which story, as a news editor, would you want to know more about? And which, as a reader, would you turn to first? The shrewd and responsible editor will certainly quiz the sports reporter, perhaps to discover, with a series of increasingly exasperated sighs, that the ‘captain of the e ngland team’ is in fact the acting-coach for an amateur sports lobby that told the Coventry e vening t elegraph two years ago that it had dreams of entering the 2012 Olympic bobsleigh event; that the junior minister was not a politician but someone who had once been a theological student and a lay reader in a dissenting congregation in Beckenham, Kent; that the presence of class-A substances had yet to be confirmed, and might turn out to be Bacardi Breezer; that the bed was an ornamental flower display in a traffic roundabout; and that the tarts were later identified as boxed pizzas rather than frozen quiches. The sports reporter’s story could still end up on the front page, as a droll little diversion, or an ‘and finally …’ on the evening news. t he science correspondent’s pitch will be met by the blankest of blank stares. The conclusion to draw from this thought experiment – not a thought experiment at all, but rather a simplified version of the countless hurried negotiations, debates, discussions and plea-bargains that go on throughout the day in any news organisation – is that while overstatement is not necessarily a good tactic, understatement is synonymous with no statement at all; and that whereas pride may indeed goeth before a fall, humility never even gets up off the ground.

Now, examination question number two: which journalistic specialisation is the most likely to produce news that has never been written before? The answer is remarkably straightforward. British sports editors know, even before the season begins, that e ngland will crash to defeat; political correspondents can predict that the government will be on the back foot by the end of Prime Minister’s question time; show business writers know that today’s pop star favourite is on a career trajectory likely to run from top of the charts to rehab at an exclusive celebrity bolt-hole and then back from drugs hell to an appearance on a high profile television chat show. Science writers, however, can and do write things that not only have never been written before; they can and do write things that nobody could ever have *imagined* writing before.

t hey can tell an unastonished readership – the paradox of the news business is that real news always takes rather a long time to sink in, and therefore to astonish – that 96 per cent of the universe is composed of a mix of undetectable dark matter and unknowable dark energy and that all the stars in all the galaxies together add up to a trifling fraction of the mass of creation. They can reveal that a laboratory in Scotland that nobody has ever heard of can replicate life: take one single cell from a sheep that is already dead, grow it in a laboratory dish, stick it in an empty egg, jolt this strange artefact Frankenstein-fashion to galvanise a new life, and bingo! Behold a clone, an identical sheep. They can produce a thrilling story of an archaeologist who pokes around inside an Egyptian tomb that has been known for more than a century as plundered space of no historical interest, and that is likely to be surrendered for a car park, to discover that this dusty little hole in the ground is not only the largest burial chamber in the entire Valley of the Kings but the tomb of the sons of r ameses the Second: Shelley's o zymandias, and the pharaoh most frequently linked with the biblical story of Moses, the plagues of Egypt and the Angel of Death that carried off all the first-born. And they can deliver not just the marvels that people can imagine – all three stories could have been produced as fiction – but marvels that no ordinary reader would ever have imagined.

How many barristers, bartenders, barbers or boilermakers have ever thought of themselves as coherent co-operative collectives of 100 trillion cells of 300 different varieties? o f those that might occasionally have done so, how many imagined for themselves the probability of tiny populations of conjurer-cells, creative agents that produce new tissue to repair failing fabric, now known as stem cells? And how many have ever worked out for themselves that at some point in the wonderful journey from DNA-inside-an-egg to sentient-reproducer-on-two-legs, there must have existed an embryo state consisting almost entirely of these stem cells, any one of which contained all the potential to replicate a whole human being or any single part of that being? a nd how many might then have wondered if these cells could be collected, cultured and transplanted, like cuttings from a herbaceous border, to ameliorate suffering, extend life and perhaps even cheat death?

And now, examination question number three: how many metaphors, similes and analogies have i perpetrated in the last 1300 words? h ow many examples of onomatopoeia, alliteration, metonymy, hyperbole or shameless cliché have i used so far? To what extent have I disgraced the dignity of science journalism by my indiscriminate resort to figures of speech? The answer to all three is: I don't know. I wasn't counting. The language of ordinary human commerce is composed of metaphors that are now used so incessantly they are no longer recognisable as imagery. I may draw the line at cliché, but if I sift the evidence, I shall find a cornucopia of weary images. You may give me the green light to try a new approach, and I shall certainly try not to jump the gun, but in doing so I shall be sailing against the wind. t he least i can do is to swerve around an unfortunate mix of metaphors, and the best thing i can do is to devise metaphors that have some freshness and force.

a s for hyperbole, i give up immediately. t he act of writing about something – to choose one topic from the hundred or so potential topics delivered every day in the scientific press – is to hype it. I have chosen this finding rather than that, or the other, so it must be more important, more compelling, more exciting. i select, therefore I hype. The more interesting question is: does this act of inevitable hyperbole represent some kind of unconscious dishonesty or unthinking error on my part? o r would it be an even bigger error if i didn't mention it, missed the story, failed to pitch it to the news desk? I am as a science writer confronted, when i open *Nature* or *Science* or the *Proceedings of the Royal Society*, by papers that consist of a series of unemotional statements, hedged with caveat and festooned with proviso, couched in deliberately passive sentences, and phrased in wilfully opaque language. To do my job, I must convert these into narratives calculated to make people not just read, but as they read, to experience a sensation of excitement, amusement, alarm, disgust or delight, because if i do not offer this reward of sensual experience, they will not read what i write. Will the scientists to whom I talk help me in this process, and if they do will they be co-conspirators in an act of hype and the production of a sensational report? a nd if they refuse to help me, and therefore refuse to explain themselves to the public, then what precisely is their responsibility to the taxpayers who financed their research, or the consumers who might one day invest in its products? And suppose the scientists take the initiative, and approach the science writers? Let us take a case-study, but one told by a journalist, and which therefore incorporates all the sins of journalism, as well as some of its virtues.

o n 6 n ovember 1998, i wrote a front-page story for *The Guardian*, headlined 't he human cells that will revolutionise medicine.' it was based on a report in *Science*, and in the *Proceedings of the National Academy of Science*, on experiments in the US financed by a big biotech business. It was, I think, the first time i ever used the words 'embryonic stem cells' in *The Guardian*, or anywhere. o n 5 September 2005, i wrote another front page story for *The Guardian* headlined 'Stem cell hopes distorted by arrogance and spin'. it was a report of a presidential address to the British a ssociation by the fertility expert, and member of the h ouse of l ords, r obert Winston. in his speech, he warned that the use of naïve press hype and headline grabbing medical spin by journalists, and perhaps by some scientists, about the potential pay-off for embryo stem cell research could lead to a dangerous backlash from a disappointed, impatient or even cynical public, especially as any successful treatments were many years away.

it was, as it happens, the last time that i used the words 'embryonic stem cells' in *The Guardian*, because I officially retired a few weeks later, so I missed the drama of the Korean breakthroughs that never were. But even without those elements, my story happily traces a seven-year trajectory that runs from wide-eyed optimism to mature, but not yet despairing, realism and one in which i cheerfully plead guilty to charges of hype, spin, naiveté and ruthless headline grabbing. During those seven years, i also employed a variety of outrageous images in an attempt to highlight the drama of embryonic stem cell research and the political contortions that took a highly contentious technology – contentious because, even during the tenure of President Clinton, the US administration would not finance it – from dream to … well, still a dream, but a dream with cautious approval from the u K h uman Fertilisation and e mbryology a uthority and, at the time of writing, some potentially encouraging results.

i once said stem cell research offered the hope of discovering a new 'fountain of youth'. i used the metaphors of alchemy, and the philosopher's stone, to describe the way hospital scientists had begun to conjure nerve cells from bone marrow, or muscle tissue from fat harvested by liposuction. I used science fiction terminology such as ‘turning back the biological clock’ and ‘reversing the ageing process’. in one trope, borrowed from the Brothers g rimm, i called stem cell technology ‘medicine’s answer to the magic tablecloth’: spread it out, and it would serve up whatever you wanted. I suppose I should look back and wonder at the nerve of it all, except that of course i do not. You don’t grab headlines by describing embryonic stem cell research as an expensive, laboratory-based technology of unproven merit guaranteed to lead to many years of frustration punctuated by small flashes of enlightenment. And what reporter fails to grab a headline when he can, especially with the willing and enthusiastic encouragement of a suite of university laboratories, a chief medical officer of health, distinguished scientists from the n ational institute for m edical r esearch, some very bright people from the biotech world and, of course, the occasional Labour peer with a background in fertility science? interestingly, we – my colleagues from the broadsheet newspapers, the BBC and i – were, it now seems to me, all willing co-conspirators in the great embryonic stem cell technology conjuring trick: we helped a relatively small group of scientists to launch a debate on an arcane and seemingly implausible technology, and then to push it through a series of forums towards a final vote in two houses of Parliament.

Why did we do this? Why did this particular branch of biology get what publicity agents would call ‘good press’ when other scientists – may i mention genetic engineers and food scientists at this point – got a very hard time from the media? One answer is that scientists encouraged us to see their point of view and quite frankly enlisted our help: that was flattering, and flattery is a powerful weapon. As Humbert Wolfe once observed, you cannot bribe or twist, thank God, the British journalist, but seeing what the man will do unbribed, there’s no occasion to. But there were more convincing reasons too. Embryonic stem cell research looked like a very good story: good in the sense that it seemed as if it could save lives and halt hideous degeneration; good in that it could invoke images of celebrity victims like *Superman* star Christopher r eeve and world champion boxer m uhammad a li every time somebody used words such as spinal injury and Parkinson’s disease; good in the sense that the British could for once seize the initiative; good in that it seemed to provoke a reflex denunciation from the Pope, the US religious right, the British Conservative shadow cabinet and the kind of all-purpose expert routinely solicited by certain sections of the media to denounce anything that smacks of playing g od, opening Pandora’s Box or sliding down the slippery slope.

a nd, of course, it offered a real debate: is a fertilised egg or a blastocyst a human being, or a potential human being? Or is it just a single chip in a whole spread of investments on the biological stock exchange, any of which might pay dividends or spontaneously fail? But there was another reason for the helpful attitude of the British broadsheet press. Thanks to 18 years of crazed Thatcherite ideology – the Conservative government of 1979–97 tended to regard science as a luxury activity, like opera, and its practitioners as mere nuisances – scientists had somehow achieved martyr status. And the British press likes the underdog and prefers to attack the overlord. Those scientists who told us – I am drawing on the lessons of more than two decades of science reporting – that mad cow disease could not possibly cross a species boundary and infect humans; or that nuclear material could not possibly have been released from a controversial nuclear power station; or that GM material did not need to be identified on food labels because it could not in any way be dangerous and anyway it would inconvenience m onsanto; those scientists had adopted the overlord posture, and frankly it was a pleasure to challenge them, as well as a democratic responsibility. But the embryonic stem cell debate was a model of how such a debate should be conducted in a democracy, and the broadsheet press backed it enthusiastically. Of course we should have been more challenging. But how challenging could we be, when a researcher's only honest answer to the question 'Could you really make Christopher Reeve walk again with embryo stem cells?' would be either 'We don't know' or at the most optimistic 'm aybe not'. t o have hammered on such a point would have been to spoil a good story, and the embryonic stem cell story, as I have pointed out, looked like a great one. Great in the tradition of antibiotics, or test tube babies, or open heart surgery: science, in a word, that could make a difference to all of us. The real challenge was to tell such a story at all: marvels like antibiotics and test tube babies were easier to explain after the event. But here was a story that had to be told before it happened, or it might never happen.

But there is another, deeper reason for what you might call the half-informed consent of the British press. Biology itself is a great story.

t here are three great stories in science: where the universe came from, where life came from, and where we came from. a nd biology has bagged two of them and used them to spin yarns that reflect the ambition of Homer, the drama of Shakespeare, the comedy of Balzac and the menace of Mickey Spillane. When i was born, no one had even heard of Dna and hardly anybody had heard of antibiotics. Thanks to science, my face is not pitted by smallpox, my lungs are not scarred by tuberculosis and my legs are not withered by polio, but i am old enough to have been at risk from all three. When my children were born, some people certainly knew about DNA but nobody, anywhere in the world, knew how to use it and very few people believed that it could ever be used. n ow, the whole world of biology can compare the genomes of mouse and man and dog; nematode and fruit fly and fugu fish; thale cress, rice and banana; malarial parasite and meningitis bacterium. Researchers talk confidently – confidently, not necessarily accurately – of human origins, and the long journey of *Homo sapiens* from o lduvai g orge to o stend and the o rinoco. t here are now forms of biology that no previous generation could have imagined: proteomics, for instance, and glycobiology; evo-devo and evolutionary psychology and even prebiotic chemistry. t here are researchers who think that they might be able to use recovered DNA to resurrect the woolly mammoth; and others who have been able to link whales with, for instance, even-toed ungulates, on the evidence of new palaeontological finds in Pakistan; and yet others who think they should try to 'barcode' all life on Earth, and download it onto a handheld computer (see Strauss, Larson, this volume).

t here are bioscientists who hope to enrich the world, and possibly themselves, by treating genetic material as so much l ego or m eccano and bolting interesting evolutionary developments from one kind of creature onto closely related, or even distantly related, species in the hope of raising a new kind of commercial winner.

a nd there are yet others who want to exploit not the common inheritance of all life, but the uniqueness of the individual: seize a handful of stem cells, or better still foetal blood or embryonic stem cells, and use these to grow new things, shape them into new organs or new tissues, and implant them: the ultimate in self-repair. t he biological revolution – the revolution metaphor is a cliché, but i cannot think of a better word – is one of four or five such scientific upheavals that have occurred not in my lifetime but in my children's lifetime: think of the things that have happened since 1965 in the exploration of space, in the development of earth and planetary sciences, in computing, particle physics and cosmology. a nd of course, think of the spread of figurative investment, the array of opportunities for metaphor-manufacture and hyperbolic handiwork that such advances represent. Thanks to the searchable database, I can confirm that as a reporter I was aware of these temptations. o n 26 February 1996, i began a report of a visit to the Space Telescope Science Institute at Johns Hopkins University, in Baltimore, with the words:

> The Hubble space telescope is not just out of this world, it is beyond metaphor. It flies 360 miles above the Earth, but higher than hyperbole. Nasa says that were Hubble in Washington, it could resolve two fireflies in Tokyo, 10 feet apart. It can fix an eye on the most distant part of the heavens and photograph galaxies 12 or 14 billion light years away. When you talk about Hubble, adjectives like cosmic or astronomical become understatements.

For good measure – and as science editor, i probably wrote this as well – the story was headlined 'All star epic at the universal studio'. So I knew what I was doing, and i certainly plead guilty to the use of metaphor and hyperbole, and i certainly do not plead extenuating circumstances. n obody forced me to do such things, and I even confess to a certain enjoyment in the confection of metaphors.

i shall conclude with yet another, a metaphor i have used often in the past, and repeat with no apology. n ewspapers exist to be read. t hey exist only because they are read. i am fond of drawing a lesson from that fabulous archive of popular stories, *The Thousand and One Nights*. t he Caliph customarily consumed a fresh wife each night, and then beheaded her so that she could never be unfaithful to him. Queen Scheherazade kept her head not by carnality but by fulfilling an equally profound human need: she told stories. She had to tell stories every night, and keep the Caliph excited, and keep it up for 1001 nights, or she would die. So she fashioned entertainments that have endured for centuries: of a laddin, a li Baba, Sinbad the Sailor and so on. n ewspapers follow the same imperative: the day the readers stop reading, they stop buying, and the newspaper dies. So even the science stories in newspapers are just that, stories. They are drawn from the world of science. t hey are told for serious purpose. But they are told so as to give pleasure. it is not our business to advance the public education in science, except by the way, and as a kind of happy accident. It is our business to be read, and to be read, we use – without apology or embarrassment – tools that have kept storytellers in business since Homer filed the first frontline despatches from a military stalemate at the walls of Troy. These tools include a wide range of figures of speech, among them metaphor and hyperbole, and although these are tools that may be used clumsily, or even very clumsily, all I can say is: just try writing without them, and see how far you get.

Chapter 10

m etaphor Contests and Contested m etaphors: From Webs Spinning Spiders to Barcodes on Dn a

Stephen Strauss

Recently, a young journalist interviewed me in preparation for an article she was writing about the future of science journalism. After wading through my considerable harrumphings about how that tool of creative destruction known as the Internet is macerating all traditional media, we got around to her asking about my bona fides.

Certainly i must have studied science, she said. Certainly i must have gone to journalism school.

Certainly not, i explained, going into a little song and dance i have developed over the years in which i explain how i couldn't graduate from high school without a science course, so I took physics, and I couldn't graduate from university without another science course, so I took chemistry. But that was it – not to mention my first job in journalism saw a history and English major writing for what in North America is called the supermarket tabloids.

'But didn't you feel really nervous interviewing scientists?' she asked in quite literal blue-eyed, blonde-haired wonder.

'Well, a little at first,' I admitted, but then said that quickly shifted when i started to force them to feel nervous around me. t he way i did this was by demanding early and often in interviews that scientists recast their science into a metaphor which some ordinary person – I didn't, but could have said, 'like me' – could use to understand their findings. Often the scientists were flummoxed, and so I ended up regularly working with them to come up with such a metaphor and in so doing turned my ignorance into something that worked to both our advantages,' i told her.

'Cool,' she replied.

Cool indeed, and this fascination with metaphor has played itself out in two ways. One is what is now a nearly two decade long personal effort to make science metaphor less worn, inappropriate, uninformative, bored and lazy. t he other is to wonder whether truly good, maybe too good, metaphors and analogies can actually change the science they are used to describe.

t he following will explore both avenues of thought in two areas and the contradictions which emerge from them, but it is an analysis that comes with a caveat. What you will read is a combination of reportage and analysis but not strictly speaking academic research. I remain, as always in my journalistic life, a person less of premeditation and more of observation and happenstance.

t he web that spins the spider

l et me start by telling the story of my attempt to give birth to a better metaphor. in 1990, while a columnist at *The Globe and Mail* newspaper in t oronto, i held a metaphor contest (Strauss 1990a). The task, I told my readers, was to improve the journalistic way of describing DNA. I pointed out that when I casually surveyed science writers at the a merican a ssociation for the a dvancement of Science annual meeting everyone seemed to employ a different image. Some called it a 'blueprint', others 'chemical building blocks,' or the 'molecule of heredity' or 'the spiraling staircase of genetic information' or 'life's biochemical photocopier.'

t he problem, i wrote, is 'that Dna is both potentiality and actuality. Yes, it is a blueprint, but a blueprint that in a certain way transforms itself into the building it is designing. it is photocopier, photocopy and the original.'

Accordingly I asked readers to, in six words or less, come up with a better metaphor.

t here were 93 individual entries and 150 separate metaphors submitted to the contest (Strauss 1990b). The shortest was the word LIFE, written in letters six centimetres tall. t here were funny ones, 'Dna – Death's n atural a lternative', 'Dna – the Pete and repeat of biology', 'Dna , life sentence', and 'Dna , the ingredients in the muffin of life'.

t hen more serious ones. Dna was 'chemical soul', 'hard-wired Karma', 'life twine', the 'carbon original of life.' But my favourite, and the one which won the prize of being called the best of the best was t revor Spencer r ines' entry: 'Dna : the web that spins the spider'.[1]

I awarded him the non-remunerative first prize in a subsequent column and did nothing more until i started this chapter. t hen i wondered how r ines, a u niversity of t oronto astrophysics student who was in the process of switching over to become a music major, came up with such a startling image. His explanation in a telephone conversation was both instructive and voluminous.

'it was the large and the small, the whole cosmic zoom approach,' he told me.

1 See Strauss (2009) and a discussion of this metaphor as well as proposals for alternative metaphors by the readers of Strauss's article: http://www.newscientist.com/commenting/browse?id=mg20126965.800). Here are a handful of examples: machine code of life, soup of life, Quadrary Code of Construction, genes are the cogs behind the clock face, self-extracting ZIP, and a whole list of metaphors by 'Julian': the ouroboros of life, the replicant nexus, the molecule that binds us, the twist of fate, the living reflex, the self-illuminating mirror, the self-organizer, the spark and seed of tinder, the paragon of autocatalysis, t uring's Biological m achine, and so on.

‘You can think of the spider really made up of small webs of things, but also if you look at a DNA molecule down its axis it looks like a spider web. Then again the idea of the molecule that unzips itself and puts itself back together reminded me of spiders consuming their own web and then re-spinning it. Finally of course there is the whole Web of Life image embedded there too’ (Rines 2008).

Personally what I liked about it, no loved about it, was that it solved the issue of being and becoming and then being again in an image i could see, and repeat to myself over and over without becoming bored. it was deep poetry and it was also, i can say with the wisdom brought on by internet searching, used only once again by anyone. t his invisibility remains even though everyone over the years i have described the metaphor to – scientists, lay people, people i bore on planes – loves it. Why the lack of traction and appeal from everyone except maybe myself? For the longest time i believed the answer was exactly because it caused you to pause. It made you think. It stopped the flow of the sentence, of the explanation. ‘The web that spins the spider’ was – and this is its genius – *too good*.

So what I believed I had learned from the experience is that a scientific metaphor can talk, but it can’t shout, and it most definitely can’t mesmerize.

But my thoughts on this recently have begun to change.

A kind of mental reformation of webs and spiders grows out of a column I wrote on metaphor and autism for the Canadian Broadcasting Corporation’s website (Strauss 2007).

t he impetus for that was a highly technical paper published in *Nature Genetics* entitled ‘*Mapping autism risk loci using genetic linkage and chromosomal rearrangements*’ (Consortium 2007). After it appeared, I found myself wading through a variety of media stories describing how a new gene mutation associated with autism had been discovered. ‘Associated’ is the key word here as the paper reported a gene called neurexin1 statistically correlated with an increased risk of autism after close to 1400 families where autism existed were surveyed. a s well there was a place on chromosome 11 which also seemed to be associated with the conditions. All of which sounded significant unless one stopped to consider that up to 100 genes are now believed to be linked with autism and some of these had been previously found on chromosomes 22, 3, 7, 17 and the X chromosome (Wikipedia 2008).

It was, as I was looking at the news from a few days’ distance, the archetype of what is sometimes called ‘middle middling’ science, and yet this slender advance was regularly described as a ‘breakthrough’ and was considered so important that 197 news outlets had reported about it.

I judged they had written their stories in part in response to scientists involved in the study who had been quite zealous in their efforts to come up with a metaphor that conveyed deep significance. For example, Nancy Minshew, the director of the u niversity of Pittsburgh’s Collaborative Program of e xcellence in a utism, told the Pittsburgh Post-Gazette: ‘It’s sort of like a puzzle. The more pieces you get, the easier it gets’ (Srikameswaran 2007).

t hat sounds sensible until you stop and consider your own experiences with jig-saw puzzling. Generally, the more pieces there are, the harder the puzzle and the longer it takes to put the puzzle together. If Minshew's analogy is correct, what had just happened was that the new finding meant deciphering the puzzle of autism would become a bigger, more complex task than we had thought of before; still, maybe it was a question not of more pieces but of extremely significant pieces having been found.

Dr. Peter Szatmari, head of the Division of Child Psychiatry at mcmaster u niversity in h amilton, o ntario, who also participated in the study, had this to say to the Canadian Press about the relationship of the pieces to the whole: 'It's like the corner piece of the puzzle. It's a lot easier to work on the rest of the puzzle if you've got the corner piece' (Canadian Press 2007).

a gain it is a simple and appealing comparison but it assumes a 'puzzling' thing.

The first is that the genetics of autism somehow forms itself into a four-cornered square. But there was nothing in the paper which suggested that autism wasn't going to turn out to be an extremely oddly shaped centagon in which, effectively, every gene piece might be seen as a corner of one sort or another.

t he puzzlement of puzzledom expanded in my mind after reading that h ilary Coon, a research professor at the u niversity of u tah and another participant in the study, told the Salt Lake Tribune (Rosetta 2007) that their results were 'a huge piece of the puzzle.' However, the reporter didn't ask how huge was huge. A piece half the size of the entire puzzle? A quarter? A fifth? This was relevant because Stan n elson, a geneticist at the u niversity of California, l os a ngeles, and another co-author of the study, told *USA Today* (Szabo 2007) some genes likely could have a 20 per cent influence on autism and others a .2 per cent. Again, no indication of the size of the newly discovered gene.

So I started to apply a mental yardstick to the metaphor. Since genetics itself only explains somewhere between 80 to 90 per cent of autism cases to begin with, we have a certain intrinsic limitation on genetics' contribution. a ssuming there are 100 genes involved, if neurexin1 contributed, say, two per cent toward the total autism disease package, that would make it a large piece of the puzzle relatively speaking but still insignificant.

a s i got deeper into the puzzle of metaphor i thought that maybe the data in the paper will help us resolve the 'how big is a big piece' conundrum – but no. t he authors almost subversively announced in their article that 'none of our linkage results can be interpreted as "statistically significant" because we have performed numerous analyses on the data.' So we have pieces, but we don't know how big, and worse, we can't even be sure they are autism pieces at all. t hey might upon further examination turn out to be pieces of some other puzzling bit of a non-autistic Dna reality.

With these conundrums before us, you might think that the easiest thing to do would be to switch metaphors and work our way out of the palace of puzzlement entirely. And indeed that did happen. 'Not only have we found which haystack the needle is in, we now know where in the haystack that needle is located,' Szatmari also told the Canadian Press (Canadian Press 2007).

n ow the problem is that we previously had been told that there are many needles – if we assume that each of the 100 or so autism-related genes is a figurative needle – and many haystacks, if we assume each chromosome or section of chromosome is a stack of hay.

So at the very most we haven't found *the* needle in the haystack, rather one of *many* needles in *many* haystacks, but even *that* turned out to be questionable.

t he *Nature* paper also contained what might be termed a negative twist on previous evidence. It didn't find any correlation between autism and genetic abnormalities on chromosomes 2, 7 and 17, chromosomal haystacks that previous research argued contained autism-gene needles. So maybe it would be more accurate to say we have found *no* needles in some haystacks we thought had needles in them and *some* in haystacks we didn't know had needles, but again, given the problem with the statistical significance of anything, that might have to be rephrased. n o needles *yet* found in some perhaps haystacks but that might not mean the stacks will turn out to be needle-less in the future.

With this as a background I then suggested that the paper's results presented more an enigma than a breakthrough, and consequently more accurate (although less likely to appear) headlines describing it should read: 'As more genetic pieces of autism are found, autism becomes more puzzling' or 'scientists looking for autism genetic breakthroughs slide a little ahead, and in so doing find whole field slipperier.'

a nd then i thundered, 'But those blurry images aren't going to get a story onto the front pages. In science journalism enigma doesn't sell.'

But nearly two years later I find myself increasingly less certain that it was just sloppy metaphors and journalistic laziness at work when autism genes were being described. t he reason bad images were used is because we don't have a good one in a world in which every hour the human genome is turning out to be more and more a paradigm of puzzlement. t oday we have come to understand that individual genes produce not a single protein – the old definition of what a gene was – but on average 5.7 different 'transcripts' – that is, molecules of various kinds. We have discovered the same genes in different cells produce different transcripts, not to mention that what is called *epigenomics* now tells us that new cells inherit a variety of other molecules alongside DNA. And finally there appears to be a huge quantity of RNA proteins floating around the body which do – well, we're not exactly sure what they do (Gerstein 2007; Pennisi 2007; Pearson 2006).

What this means, the author of a recent article in *Science News* wrote in a particularly imagistic way, is that scientists 'are revisiting the very notion of what a gene is. r ather than being distinct segments of code amid otherwise empty stretches of DNA – like houses along a barren country road – single genes are proving to be fragmented, intertwined with other genes, and scattered across the whole genome' (Barry 2007).

t he confusion is so great that n obel prize-winning biologist David Baltimore has suggested that DNA is 'a reality beyond metaphor' (Baltimore 2000).

However, because we – scientists and journalists – continually have to talk about Dna and its operations to the general public, the search for a primal metaphor hasn't stopped but in a way has just gotten more convoluted.

There have been various recent suggestions, ranging from Israeli kibbutzniks getting married and setting up new communes (Avise 2001) to music in a variety of its incarnations (Porta 2003; Lopez 2007). To my mind these all fail for exactly the same reasons the often quite mechanistic genomic images failed in 1991 – they don't capture the complexity of biology's weaving/being woven process. a ccordingly i now argue as strongly as i can that even if it has been ignored for nearly 20 years, the lovely, enigmatic, mesmerizing image that t revor Spencer r ines coined to win a casual contest sounds increasingly apt. m ore and more Dna isn't *like* 'the web that spins the spider', it seems to *be* that image – only given what we now know we should probably make the sentence 'the *webs* that spin the spider.'

What we have in the twists of DNA is some place akin to one of those cobwebby corners where a spider has spun a variety of old and new webs which interlace with one another. The links between DNA strands aren't direct; the spinning itself remains mystery; the appearance of the spider at the end of the process is still a wonder; but what we get from the Rines' metaphor is a sense of networked amazement.

t he spinning/spun imagery has the potential to let the autism researchers i so slagged for their clichéd metaphors now tell the world: 'We have found one more strand in the genetic web which spins autism.'

m aybe webs spinning spiders is not the sort of comparison you put on a grant application. It's definitely not a soothing image which makes people suffering from gene-based diseases feel a cure is at hand. t he web that spins the spider still isn't short, curt or obvious, but nonetheless it does give readers a feeling for genetic complexity's gnarls and contradictions and convolutions. it does feel, in a very deep way like a wonder, a winner, but more than anything else, it feels true.

When the metaphoric cart leads the science horse

DNA barcoding is a metaphor that as a journalist I have been watching emerge and quite literally take over the taxonomic world. But it as well is a metaphor whose history and dimensions have yet to be sufficiently chronicled. What a person finds in the barcoding image is something which seems to be the exact opposite of the problems of likening DNA to anything else; that is to say the barcoding metaphor has proven *so* good, *so* true, *so* easily understandable that it is almost impossible to imagine the science underlying the technique it describes existing without the barcoding reference point.

But before we get to that, let me give you some background.

If you key in the words 'DNA barcoding' into a Google search field you find that at the beginning of November 2008, 69,200 references appear. Looking in Scholar's Portal reveals that 1710 articles using the words 'Dna barcoding' have been published in journals, 1163 of them peer reviewed, and that 37 conferences and one book have produced items discussing various aspects of the technique and its applications. The Consortium for the Barcode of Life (CBOL) based at the Smithsonian institution in Washington has brought together 160 member organizations from more than 50 countries who are involved in efforts to determine species by looking at their DNA (CBOL 2008).

in addition to individual country efforts, biologists across the planet are trying to barcode all – let me stress the word – *all* the world's birds and fish and mosquitoes and fruit fly species. They in part can do that because there are now 'barcoding factories' like the $30 million facility in Guelph, Ontario which can, via its robotized, automated, DNA sequencing machines, identify 50,000 species a year.

This is quite a remarkable accomplishment considering that the first paper describing the approach and using the metaphor – 'Biological identifications through DNA barcodes' – was only published in February of 2003 (Hebert 2003). That paper showed how biologists at the University of Guelph were able to take the mitochondrial gene known as cytochrome c oxidase I (COI) and, in their words, 'derive from it a global bioidentification system for animals.' That is to say they could determine from changes in the Coi gene's Dna whether a creature belonged to one species of animal or another.

While the paper reports on the identification of various groups of animals, it grows out of analysis of butterfly and moth species which lead-researcher Paul h ebert, in very 19th century naturalist fashion, had literally caught in his own backyard. Moreover the paper predicted DNA barcoding would become the future of that dusty scientific field known as taxonomy, a discipline whose basic theoretical approach – if something looks different and acts different, it *is* different – they argue hasn't significantly changed since Carl Linnaeus first established taxonomy's principles in the 18th century.

What was not stated in the original paper was the genesis of h ebert's metaphorical term used to ascribe COI's unique marking of species differences – that is, 'barcoding'.

t he metaphor appears because in 1997 or 1998 (h ebert in 2008 is not sure exactly which year) the Guelph biologist had been shopping as usual in his neighbourhood Zehr's Market. Wheeling down a lengthy aisle he idly regarded the long and short barcode lines on the store's products, what the grocery trade calls SKu s or Shop Keeping u nits. e ach one was fundamentally individualized, that is to say each 15 ounce Campbell tomato soup can had exactly the same bar-code (*nota bene*, my change in spelling is *not* a mistake) or Universal Product Code (UPC) as it is sometimes called. Bar-coding provided Hebert with an analogical *aperçu*, what David Schindel who heads up CBol describes as a 'grocery store moment' (Schindel 2008a).

'I remember swiveling over and looking at the barcode on a can and thinking, 'hmm, pretty short, lots of numbers, lots of information, why can't we do that in nature with species Dna ?',' says h ebert in an interview a decade later (h ebert 2008).

What is interesting scientifically is that he thought of this technological analog for his research before he had definitive evidence that his approach could in fact produce DNA-based species identification in animals – and perhaps in all living things. What he did do was a little back of the envelope calculation to determine how many base pairs one had to look at to differentiate all the millions of species on earth – that is to say was Dna barcoding practical?

Hebert et al. recapitulate this thinking in the introduction to their 2003 paper: 'In a very real sense, these sequences can be viewed as genetic "barcodes" that are embedded in every cell. When one considers the discrimination of life's diversity from a combinatorial perspective, it is a modest problem. t he u niversal Product Codes used to identify retail products, employ 10 alternate numerals at 11 positions to generate 100 billion unique identifiers. Genomic barcodes have only four alternate nucleotides at each position, but the string of sites available for inspection is huge. The survey of just 15 of these nucleotide positions creates the possibility of 415 [billion] codes, 100 times the number that would be required to discriminate life if each taxon was uniquely branded' (Hebert 2003).

t he reaction of some of h ebert's peers to the metaphor/analogy was somewhere south of doubt and north of disdain. t he problems seems to have been from the very beginning that it was difficult for Hebert's fellow scientists to differentiate barcoding as metaphor, from barcoding as an analogy to supermarket barcoding, from a literal statement that nature/g od somehow had gone about putting a species code in the Coi gene of each species.

For example, u niversity of a lberta biologist Felix Sperling wrote in 2003 shortly after the first paper was published: 'Like Martha Stewart, J.K. Rowling, and Oprah Winfrey, Hebert has identified and capitalized on a latent yearning for something that is missing from our daily lives: Dna barcodes hold out the promise of a simplifying elegance that is both broad and deep, and tames the confusion of life.' a nd yet, 'too bad it won't be able to deliver the goods' (Sperling 2003, and see Larson, this volume).

Hebert looks back at the beginning of his efforts with a certain amount of trepidation still in his voice. 'i got violent negativity from some intellectual colleagues who accused me of all sorts of intellectual deficits largely linked to the fact that barcodes do convey with them a certain sense of typology, and typological thinking is about the worst crime you can be accused of in evolutionary biology.' t ypology, he then explains, refers to the pre-Darwinian Biblical/a ristotelian notion that each species was somehow created separately and distinctly. t his 'creationist' paradigm continues to engender scorn bordering on loathing. a s an example, a recent article on barcoding in the magazine *Wired* contains the following description of why barcoding is still rejected by some:

> a species is a cluster of genotypes, none of them identical, even within the same brood. implicit in the word barcoding is the notion that the creatures of e arth comprise a mosaic of stable kinds. This made Hebert's critics laugh, because it is a common idea about species among the uneducated. it predates Darwin by thousands of years.
>
> 'We're not accusing Hebert of being a creationist, just of acting like one,' says Brent m ishler, director of the Jepson h erbarium at the u niversity of California at Berkeley (Wolf 2008).

Furthermore, while it seems the violent opposition to the barcoding metaphor/analogy is diminishing – the sheer number of papers using the word providing the quintessential evidence of that – a new line of metaphorical attack has arisen in the scientific community. Now critics say the trouble with the imagery is that barcoding's ability to discriminate biological species isn't nearly as accurate as the supermarket markers, and thus the technology is unworthy of being likened to a barcode.

Consider a press release from Brigham Young u niversity describing a paper published in a ugust 2008 that detailed problems with the Dna barcoding methodology: 'the approach as currently practiced churns out some results as inaccurately as a supermarket checker scanning an apple and ringing it up as an orange' (Brigham Young 2008).

And finally, Hebert's fellow scientists argued that comparing 'serious' scientific research to some supermarket price-determining technology was beyond *lèse majesté*. 't here were long and serious discussions with people who said, "Paul, you have a decent idea and we probably should pursue it but we have to get rid of that barcoding term immediately before it takes down the whole enterprise scientifically", says Hebert. There were very serious arguments that we should leave barcoding behind and call it something like 'species-specific sequence tags'. That, I was told, would have a great resonation with the scientific community, but i resisted that.'

Why not give in to the word tastes of his scientific brethren, he is asked. 'Ultimately, I think barcoding is a fun word and that alone is a nice reason to use it. Why want to be so scientifically proper as to make our science tedious, not to mention that our terminology in evolution is already metaphorical,' he says.

Still, scientists are just one community of interest. h ow did the common person respond to DNA barcoding or bar coding or bar-coding, you may ask? If there ever is an arena of metaphor research which cries out for a reader survey, it may be this one, but unfortunately such an analysis of what the general public thinks doesn't exist, so let me instead give you a sample of h ebert's experiences.

'Amongst the public I don't think that the metaphor did damage; I think it created friends. Their view was, "it works in supermarkets so why the hell would it not work for living organisms?",' he tells me.

a positive reaction, but also a problem for h ebert and others trying to explain what they were doing. From the beginning, as with the scientists, some of the general public didn't understand how to differentiate between a metaphor describing a new paradigm for species identification and a literal equivalent to an identification process they were familiar with in stores. 'The metaphor may have led to a wrong sense about what was going on. i mean, some of the early responses from the public I got were questions about whether there was a barcode plastered on organisms, or "are you are planning to glue barcode stickers on living organisms?",' Hebert reflects.

While it was relatively easy to explain away that simply uninformed point of view, the linkage of a species identifying research effort to a highly visible store technology continues to create communications problems for h ebert. in a way, as the BYu press released suggested, the metaphor is perceived by the general public as too good for the science it is trying to describe – especially as Dna barcoding has begun to be applied to practical problems. Because a Dna species determination can be made even if meat has been cooked, for example, one of the technique's applications has been as a new method of detecting food fraud.

'Just yesterday i got a call from a food processing company in Woodbridge, Ontario,' Hebert says. 'They buy squid and they are noting that the squid they are getting now is tough and not as tasty as what they were sent before. t hey believe the suppliers in Asia are sticking them with low value squid species, and so they said to me: "Can you barcode the squid we are being sent and tell me what they are?"

'a nd i said, "well i *may* be able to."

'a nd they say, "what is the problem?"

'And I said, "no problem in getting the barcode, but I don't know if I have barcode references for all species you are dealing with."'

That is, to know whether something is of one species of animal and not another, you have to compare it to a DNA reading you have previously linked to a given species.

h ebert laughs when he recounts the company's reaction to this unexpected 'problem' in the identification process. 'They said to me, "you mean you don't have live squids swimming around in tanks that you can read a barcode from?" Yeah, right, like this is modern Noah's Ark and we have all the species in the world growing in a tank. People have no clue what we are doing, really.'

Moreover, because they are familiar with barcoding in supermarkets, the public often expects the process to barcode life in the wild to be conducted with effortless efficiency. One scientific issue is that it is not equally simple to produce barcodes for different life forms. Particularly difficult have been plants and fungi, which for a variety of reasons don't store species information in their copies of the Coi gene. Explaining this again forces Hebert to confront ordinary people's difficulty in differentiating Dna barcoding being *like* supermarket barcoding, from it being *identical* to it.

> People are used to the store scanner and the notion it is immediate. You explain to them it takes us about three days to barcode a species and they still want to

> know why the hell can you just not read it immediately. The other thing they don't get is that for a variety of reasons we can't yet do barcoding for this or that set of organisms. They think: 'Scanners work on everything in the supermarket so, so should DNA barcoding.' They see our difficulties like me walking down a supermarket aisle and saying 'scanning it will work on this shelf, but over here it doesn't work.' And they find that very hard to accept because in the supermarket everything can be barcoded. (Hebert 2008)

a very different understanding about what barcoding has meant has emerged when Hebert has needed to appeal for financial or organizational support outside the taxonomic community. I ask Hebert: 'Do you think if you hadn't had the metaphor it would have affected the history of the enterprise, particularly when it came to funding?'

> i believe that really seriously. Some of the resources are contingent resources and I think some of these resources flowed because people got a quick sense from the term 'barcoding' what we were trying to do, and as you well know there are positive feedback loops to these things. Every dollar that funds this project is likely to increase the probability of another dollar being invested in it in the near future. In my view the first dollars we obtained were probably pried loose by the metaphor for barcoding.

Which brings me back to the question of whether the reaction of fellow scientists, the general public or funders would have been different if another image had been used. n o one is sure, but Schindel argues that part of what was going on in the rejection of the metaphor was a disdain for anything which not just explained the science but was really, really easy to grasp. 'One finds in basic research circles any attempt to popularize something raises a certain amount of suspicion, scepticism, jealousy. The fact that the use of the DNA barcode analogy to the Universal Product Code was so easily picked up and understood by lay people did just that,' he says (Schindel 2008b).

Conversely, for some the DNA barcoding analogy was not just an almost transcendently evocative image, but a template on which the development of a computerized, automated, analogue species identification technology would be molded.

For example, in 2004 three scientists from Rockefeller University wrote a piece detailing why barcoding was not just an apt metaphor, but in many ways an actual description of what scientists hoped to accomplish with barcoding. it is not just a useful metaphor, it is a deep and reverential analogy.

> Although new methods of sequencing and visualization have displaced the one that produced auto-radiographs that show blurry gray stripes of a gel indicating presence or absence of particular bits of Dna , the analogy between the commercial barcode and the barcode of life may be traced to it. h owever, the power of the

> analogy comes from other similarities: l arge capacities to differentiate mind-boggling diversity, ability of digits to distinguish unambiguously, rapidity and economy of identification, ability of parts of the code to distinguish categories, and avoidance of a t ower of Babel by uniformity.
>
> Speed and economy also propel use of barcodes. Behind the beep of a u PC scanner lies orchestration that began with the initial conception of bars for numbers a half-century ago. (Ausubel, Stoeckle and Waggoner 2008).

I will return to the issue raised here further down but let me leave the scientific disputes briefly by pointing out the interesting – well frankly almost ‘cutesy’ – linguistic way in which h ebert has been trying to differentiate what barcoding does in the search for species from what it does in terms of product labeling. ‘We are pretty insistent that Dna barcoding is a neologism and for that reason we insist on concatenating it,’ h ebert says.

What he is referring to is the spelling differentiation noted earlier in this piece. g enerally in the commercial world the term is written either ‘bar code’ or ‘bar-code.’ ‘What we say we are doing when we write ‘Dna barcoding’ is saying by the concatenation that it is a very different process than that which underlies store “bar codes”,’ he tells me.

Having said all this I return to my initial question of what would have happened if the barcoding image had either not been available or not been chosen? Couldn’t you have called it something else, ‘species license plates’ or ‘species fingerprints’ or ‘species ID cards’ or a ‘species phone book’ – things that are also commonly ‘read’? o f course we can’t tell for sure, but the idea gets a general ‘nay’ from people involved.

‘I think it would have been a tougher sell to get to where we are now. Barcoding is just a very simple, appealing slogan,’ says Schindel (2008b).

‘Of course a fingerprint isn’t a short digital string,’ says Hebert about one possible other metaphor. ‘But that doesn’t necessarily mean you couldn’t “metaphorize” it when talking about species identification. However, another thing is that fingerprinting is already a preoccupied space in our field. It describes the business of using rather complex DNA profiles to tell individuals apart.’

h owever, he is less sure what would have happened if you had called it Species id, or a Species l icense Plate, not to mention a Species Dewey Decimal System, or Species t elephone n umber or Species Postal Code.

t rue enough, but the reality is that when you create a Dna barcode from an analysis of gene differences you *do* end up with something that looks like a supermarket barcode (see http://phe.rockefeller.edu/barcode/blog/2008/11/07/whats-in-a-name/; see also t im Flach’s ‘barcode’ zebra, at, for example: news.bbc.co.uk/2/hi/science/nature/4251309.stm).

As a consequence I will argue strongly that none of the other suggested metaphors will give you a feeling of what Dna barcoding is genetically and how it looks physically. None. But there is something else as well: It is almost magical to stand in a grocery line up and watch while a series of bars tell a barcode reader where a SKu came from, what it is called and how much it costs – all in one instant. t he u niversal Product Code is expressing a variety of intrinsic things about a product just as the notion of species expresses a variety of intrinsic things about living beings. a Species t elephone n umber, Species Postal Code, iD, License Plate, or Dewey Decimal System doesn't do that. They are just surface labels, labels that just lie there and in a way just *are*, but a Dna barcode seems like biology in all its reproductive glory. It seems like there *is* a code underneath an animal which manifests itself in a creature which looks nothing like the code, but still is it.

Concluding thoughts

So what do I now say to my blue-eyed inquisitor about the whole area of metaphors and DNA? I would like to impart fixed truths, and major new understandings, but truthfully when I look at these two examples of metaphor and DNA all I can report back is a contradiction.

Despite having no generally accepted way of portraying Dna 's growing complexity, despite clearly needing a metaphor to explain it, genetic research plows ahead. o n the other hand, the image of Dna barcoding has become so intrinsic to our understanding of both the technology and in a way the ideology of gene-based species identification, you almost can't imagine it existing without the image.

So ultimately there is science and there is metaphor, but as far as i can tell, there is no science to metaphor.

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Part IV
Science, Science Communication and Metaphor Analysis

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Chapter 11
Should Scientists a dvocate? t he Case of Promotional m etaphors in e nvironmental Science

Brendon l arson

Introduction

Science holds an esteemed place in modern societies because the knowledge it provides is thought to be objective. In terms of Robert Merton's (1973) sociology of science, among other qualities scientists are supposed to be disinterested. While they produce knowledge for its own sake, it is generally assumed that the media, politicians and the public interpret scientific information and often misinterpret or misuse it. t his view of the relation between science and society is commonplace, but it has been undermined by several decades of research in the fields of sociology of science and science communication (see Jasanoff, this volume). In the current era, scientists are more often asked to produce knowledge that is useful. They also have to sell their ideas and obtain funding, which melds epistemology with rhetoric. in this chapter, i attempt to capture some of the tensions scientists face as they negotiate the Scylla of absolute disinterestedness and the Charybdis of unbridled advocacy. While most of this book focuses on the role of journalists in science communication, this chapter specifically considers the role of scientists themselves in the production of ethical science communication.

My case studies concern science affiliated with biodiversity conservation, a field in which there has long been discussion about the appropriateness of advocacy. While some feel it is justified because conservation biologists have a responsibility to speak on behalf of the planet, others counter that if scientists speak out they infringe their time-honoured role as purveyors of objective information. Recently, numerous scholars have attempted to find a middle ground between these extremes (Lach et al. 2003, Wallington and Moore 2005, Kincaid et al. 2007, Lackey 2007, Noss 2007). To date, however, there has been relatively little discussion about language and metaphor specifically. One philosopher, Bryan Norton (1998: 353), has concluded that scientific language needs to be 'frankly value-laden' if it is to draw attention to critical environmental issues (see also Hull et al. 2003). Some scientists show little hesitation before entering these philosophical waters, with some condoning hyperbole (e.g., Simberloff 2006) and others seeking a more neutral, objective language (e.g., Colautti and MacIsaac 2004). We clearly require ongoing consideration of the ethical issues surrounding the use of value-laden language in science communication.

i focus on metaphors because they are generally useful for explaining complex scientific ideas to broader audiences (Lakoff and Johnson 1980; Brown 2003). I am specifically interested in cases where environmental scientists advocate a particular view or promote a particular cause using metaphors. Such activism has significant consequences because the selection of a metaphor entrains a particular vision or expectation of how things might be. In considering such questions, we are expanding the usual epistemic evaluation of scientific metaphors into assessment of their social and environmental efficacy (Harré et al. 1999; Carolan 2006; Elliott 2009). The sociologist Dorothy Nelkin (1994) provided a precedent for this more in the case of 'promotional metaphors,' drawing on a case study of the deterministic metaphors used to represent human genetics (see also Nelkin 2001). She argued that scientists use 'evocative images, catchy titles, and often corny metaphors' (1994: 25) to attract an audience. Importantly, she concluded that because of their need to promote themselves, scientists are 'prone to overestimate the benefits of their work. But in doing so, they contribute to overblown expectations that will ultimately undermine their base of public support. t hus, in the interest of public understanding, scientists should restrain promotional tendencies that lead to oversell' (1994: 30).

While Nelkin was thus an early promoter of 'narratives of humility' (see Jasanoff, this volume), her notion of a promotional metaphor has received surprisingly little attention. h ere, i rely on interviews with two scientists who have recently used promotional metaphors to illuminate their use as well as their implications. In so doing I hope to expand both the breadth and depth of Nelkin's insight. I expand her discussion into a field where advocacy is arguably more appropriate – in the interests of biodiversity conservation perhaps scientists' promotional tendencies are justified, though not without confronting a series of ethical questions. While Nelkin discussed the consequences of media interviews with scientists, i also deepen her analysis by showing how scientists use such metaphors in primary research articles. n ot only the media, but also scientists themselves, use metaphors to simplify, to teach and to sell.

Case studies: 'DNa barcoding' and 'invasional meltdown'

i draw on two metaphoric case studies that have four main advantages for this analysis:

1. t hey derive from recent biodiversity science, so we can to some extent observe 'science-in-action' rather than historically reconstruct it;
2. They can each be traced to a specific publication and to promotion by an individual scientist;
3. Because of their social resonance, they have both been heavily cited in the scientific literature and covered extensively by the media; and

4. Scientists have debated the semantic appropriateness of each metaphor in print.

The first case study is DNA barcoding. Although the metaphor of a 'DNA barcode' has been utilized in a number of scientific contexts (Arnot et al. 1993; Leier et al. 2000), it now refers to the use of a short DNA sequence, from a standard location in the genome, to identify species. t his usage can be traced to a 2003 paper by Paul h ebert et al., which led to h ebert, as the senior scientist, becoming the 'father of DNA barcoding'. Strauss (this volume) tells Hebert's story of how he came up with the metaphor. t he appeal of the barcoding idea is demonstrated not only by the more than 600 citations of this paper to date,[1] but also by widespread media coverage.[2] While Dna has long been used to identify species, Dna barcoding seeks to standardize taxonomy by using one DNA sequence – potentially the shortest one possible – to differentiate among species. For many organisms, this objective appears to be met by the first 648 bases of a mitochondrial gene, COI.

Why do this? An influential conservation biologist, Daniel Janzen (2004), argues that it will lead to the taxonomic equivalent of the Star Trek tricorder (a handheld instrument for scanning alien environments). Someday, given US$ 1–2 billion in funding, people will be able to identify an animal by putting a piece of it into a handheld 'barcoder'. n ot only do proponents assume that this technology will improve everyone's access to biodiversity and their appreciation of it (for an alternative view, see Larson 2007a), but it will also help scientists to inventory biodiversity and perhaps even locate new species. it may also have diverse and undeniable practical benefits, mainly related to its ability to distinguish organisms based on small fragments – for example, fish in a market, old feathers from dead waterfowl or potentially invasive species at borders (like a species' identity card). n umerous scientists have discounted barcoding technology (e bach and h oldrege 2005; Will et al. 2005; Rubinoff 2006), including the esteemed British biologist Lord Robert May (2004), who stated, regarding the possibility that 'widgets' will allow identification of organisms within 25 years, 'I am inclined to wonder what these people had been smoking'. Nevertheless, the proposal has drawn extensive media coverage and a funding largesse. a t least in this regard, barcoding has been an extremely successful metaphor (see Strauss, this volume).

t he second case study concerns 'invasional meltdown', a metaphor that can be traced to a paper in the journal *Biological Invasions* by ecologist Dan Simberloff and his graduate student Betsy von Holle (1999). They attribute the metaphor both to a suggestion by a colleague, Peter Kareiva, and to familiarity with another metaphor in conservation biology, mutational meltdown, which describes how mutations may accumulate in small populations of a species at an

1 According to Web of Knowledge [Online], see http://www.isiwebofknowledge.com [accessed January m arch 2009].

2 See http://www.barcoding.si.edu/media.html [accessed January 2009].

increasing rate and lead to their extinction (Gabriel et al. 1993).[3] a n invasional meltdown, by contrast, concerns the effect of invasive species, or species that have been introduced from one part of the world to another. The metaphor specifically refers to the 'process by which non-indigenous species facilitate one another's invasion ... potentially leading to an accelerating increase in number of introduced species and their impact' (Simberloff 2006: 912). As another ecologist describes it, a meltdown 'implies that after a certain point is reached, ordinary intercession is impossible, and a drastic state change is inevitable – whether it occurs in a toddler in the supermarket, a nuclear reactor, or an invaded ecological community' (Gurevitch 2006: 919). While this idea does not appear to have captured nearly the attention of Dna barcoding in terms of funding and media coverage, it has been featured in recent popular books on invasive species (e.g. Baskin 2002), and 'the high visibility of certain cases … has led to increasing notice in newspapers, magazines, and even political speeches' (Simberloff 2006: 916). It is part of a broader attempt by some conservation biologists and ecologists to increase public awareness, understanding and concern about the effects of invasive species (for a more detailed metaphor analysis, see Larson 2008).

To better understand how the use of these metaphors was justified, I interviewed Dan Simberloff and Paul h ebert in the winter of 2007, upon approval from the University of Waterloo Office of Research Ethics. I followed standard protocols for research interviews, but was only able to conduct one interview, lasting about one hour, with each of them. I asked a number of open-ended questions, some general to both interviews and some more specific. The interviews were recorded and transcribed and then analyzed in terms of responses to key questions and for emergent themes. Unless indicated otherwise, quotes below are taken from these interviews, though they have been slightly reworded in the interest of clarity.

Scientists and their promotional metaphors

t raditionally, metaphors in science have been considered mere rhetoric. But were these two metaphors rhetorical or did their creators take them more seriously? in fact, both scientists appear to have adopted a realist attitude towards their metaphors and begun to think in terms of them. In this respect, they could be considered what the philosopher r ichard Boyd calls constitutive metaphors (see Turney, this volume), or metaphors that form 'an irreplaceable part of the linguistic machinery of a scientific theory' (1979: 360).

h ebert, for example, pointed out that the barcode metaphor is 'less of a metaphor than the "Tree of Life" … in that it relates directly to the major product lines of life – species'. t he 'tree of life' is a prevalent metaphor used to describe evolutionary history (e.g. the shape of phylogenetic trees, see m cinerney et al.

3 It is thus an excellent example of an intra-scientific metaphor transfer (Bono 1990).

2008), and Hebert clearly felt that it is less apt than DNA barcoding in its domain: 'I'm not sure any phylogenetic relationship looks much like an oak tree'. While it is by no means literally true to say that evolutionary history is tree-like, we can also question whether species really are product lines. Such is the power of a constitutive metaphor.

Simberloff was also a realist with regard to meltdowns:

> it's a pretty accurate metaphor … i view it almost the way we picture real meltdowns as this expanding mass of particles hitting one another and some of them are black particles and some of them are white particles and they are introduced or native, but they're all interacting. That's just the way nature is.

While he acknowledges that this is 'almost the way we picture real meltdowns', even that type of meltdown is metaphorical. m ore importantly, note that his description of nature invokes a black and white dichotomy between native and introduced species, despite some of the philosophical challenges this poses (see l arson 2007b). Further, there are neither good nor bad particles in a 'real meltdown' but here the metaphor is extended in order to support the idea that introduced species are necessarily bad. it is undoubtedly true that these species are interacting, but does it have to be a meltdown? in fact, the phenomenon under investigation is the development of new mutualistic (cooperative) associations between invasive species. in many respects, that could be seen as a positive development, and it is certainly a normal biological process. But this view is over-ridden by the negative valence of a meltdown.

We can also infer that these metaphors were constitutive because they were both used even before they were well-supported empirically. h ebert's paper, for example, proposed DNA barcoding prior to the resolution of certain critiques (Meyer and Paulay 2005; and see above), as Nelkin (1994) predicted for promotional metaphors. in the case of invasional meltdown, Simberloff's retrospective, six years after the term was coined, acknowledged that 'a full 'invasional meltdown' … has yet to be conclusively demonstrated' (Simberloff 2006: 912). There are still only a few well-demonstrated cases, including the interaction between yellow crazy ants and scale insects on Christmas island. While Simberloff maintains, 'i'd be surprised if we didn't see a number of other cases within ten years,' another ecologist notes that 'the lack of evidence for its existence is certainly not for want of attention to the hypothesized phenomenon … [it] may, in fact, be uncommon' (Gurevitch 2006: 920). And yet, the term has been in use all these years, influencing people through the media and other outlets. It almost seems as though its underlying values, rather than scientific evidence, justified its use. Otherwise, the possibility would have been stated in a more muted way; we should first know whether a phenomenon occurs before calamity is announced. a s g urevitch (2006: 920) observes, 'It is alarmist, but is it unrealistically so? We cannot know until we answer the scientific questions of its generality and magnitude'.

t hese metaphors were constitutive for the scientists and, more importantly, potentially used ahead of the evidence, but were they actually promotional in a broader social context? With regard to barcoding, h ebert observed,

> We knew that we were heading into a campaign for serious public support for the enterprise … the initial pitch was really to the broad readership and not to members of our scientific community … I would never have titled it 'DNA barcodes' if I were writing a paper for my five scientific peers … You want to be the flavor of the day.

Interestingly, here, epistemic values related to objectivity in science were already being given less precedence than ones related to social dimensions and framing.

Accordingly, Hebert encountered problems with his scientific colleagues. He stated, 'We took a lot of heat for using that term … We had an early hit on our credibility'. Some of the attacks were 'quite violent' and he received 'incredibly inflammatory emails'. Thus, he acknowledged that

> it would have been much more dangerous for a young academician to go forward with this metaphor. I don't think a young academic would have had the allies, so they wouldn't have survived the heat. it became dangerous for people to say anything positive about barcoding because of the packing instinct that, oh God, you're as dumb as the people that promoted that idea.

Continuing with the combustion metaphors, he felt that 'fighting back against the backdraft is quite consuming', but in the end it had been worth it. He credits the metaphor as 'a big asset' and one that has been 'very useful in delivering $13 million here in Canada'. it has recently delivered much more.

in contrast, Simberloff stated that he 'didn't see [meltdown] as controversial' and thus 'never conceived of it as a risk to my career or reputation in any way'. n one of his colleagues raised any issues with it. h e also 'wasn't committed to people ending up believing this was one of the major forces of invasion biology'. On the other hand, he did express some desire to appeal to both public and scientific audiences:

> I wanted people to read it and think about it. I wasn't aiming at the popular domain. i never thought there'd be anything in a newspaper about it at the time. But I didn't want it to be just another paper…, just sitting there with no one bothering to read more than the abstract.

He may have been surprised at its success, for he acknowledged that 'the meltdown metaphor attracted great attention, not only among invasion and conservation biologists, but also in the popular press' (Simberloff 2006, 912, and personal communication). Though somewhat tongue-in-cheek, he attributed part of its popularity, relative to a coincident paper on the topic (Richardson et al. 2000), to the humdrum title of the latter, ‘Plant invasions – t he role of mutualisms’. ‘[t he Richardson paper is] a better review. And it’s very rarely cited . I think if they had entitled theirs “meltdown,” it would probably be cited ten times as much’. in fact, it has been cited over 250 times.[4]

t he ethics of promotional metaphors

At this point, it is worth revisiting the question of advocacy in science. A critical issue is whether a scientist acts as a ‘stealth issue advocate’ (Pielke 2007), advocating a particular stance without stating it explicitly. When a scientist does so, adopting a guise of scientific neutrality to influence policy, it may diminish science’s reputation and its contribution to effective policy-making (Pielke 2007; Chan 2008). Ultimately, the facts in themselves never justify conservation action, as such action always relies upon particular conservation values. t he two scientists interviewed here share a concern for biodiversity and want their metaphors to contribute to its conservation. While value-laden language might assist here, ‘we can minimize the mixing of facts and values by explicitly distinguishing them’ and by using a term ‘in ways consistent with our values …, but [noting] this value judgment when defining the term’ (Chan 2008: 2). Part of the challenge, however, is that such values may be apparent to others, though not to the scientists themselves. The tension is to find enough linguistic precision for science while simultaneously selling the idea to the public through metaphoric resonance. it’s a fine line; going too far the former way prevents promotion and advocacy whereas going too far the other may cause problems for scientific credibility.

a s an example, both scientists encountered challenges arising from the unruliness of metaphor. h ebert initially felt that the barcoding metaphor was ‘beautiful’ and ‘just perfect’, and though it had ‘serious baggage in the scientific community … it resonated immediately with the public. it drew in the unwashed masses’. But there was a flip-side, namely ‘bizarre Orwellian ideas’. Some associated Dna barcoding with Craig Venter’s wish ‘to provide a whole genome sequence for every human being at birth for a thousand dollars’, to which Hebert replied, ‘We’re so far from that it’s not even funny’. e lsewhere, a comedian wrote, ‘Why don’t these darn scientists take up needlepoint and leave the world alone. Within ten years, every cardinal at my birdfeeder will have a barcode’. While this was meant to be comical, there were others who were more serious: ‘you’re destroying the world … you’re an evil person and you should stop doing this. You’re on the road to hell if you keep on. Every human will be imprinted with a barcode and you’ve started this’. t his perfect metaphor was not perfect for all occasions.

4 a ccording to Web of Knowledge [o nline], [accessed m arch 2009]. u nfortunately, Web of Knowledge does not provide the number of citations of the Simberloff and Von Holle (1999) paper.

h ebert also felt that part of the problem was biologists themselves. h e specifically felt that:

> there's a lot more angst among biologists than there is in some of the other more mature communities. i'm always interested in physics, which is intrinsically much more distant from the public and they seem to have an immense appetite for using terminologies that biologists would reject as being too flippant. You would pay a heavy price in biology for most of the terminology that's developed in physics. I think they're just simply secure in their science and let's just have a bit of fun with it then.

Some biologists and philosophers would consider this perspective an expression of 'physics-envy', for there are certainly many ways in which the biology he is talking about matters to us more – and very differently – than abstract physics (see Dupré 2007). Accordingly, physics may not be an appropriate model for biology.

Simberloff also acknowledged misunderstandings, but would have used the metaphor anyway as 'the press always misrepresents science'. a s he states elsewhere, '[Some] writers for the lay public [have] stretched it well beyond its meaning as understood by invasion biologists' (Simberloff 2006: 912). Further, he claimed that 'loose usage in the popular press has led to a backlash' (Simberloff 2006: 916, and personal communication).

From these examples we see how scientists want precise language, but in using promotional language such as this they cannot control its interpretation. Simberloff (2006) captures this paradox in his recent review when he refers to the 'meltdown' as a 'constitutive metaphor' at one point yet as 'hyperbole' at another. There are inherent risks in metaphoric communication, in part because there are differing dynamics within science, politics, and the mass media (Weingart et al. 2000). Yet scientists repeatedly blame misinterpretations on the public, rather than their metaphor. As Simberloff (2006: 916) reports, 'it is true that martial metaphors occur in the invasion biology literature [and] such metaphors become more vivid and pervasive when the popular press reports on these subjects'. In this manner, scientists disclaim responsibility for their linguistic choices. While this is reasonable at some level, as we can't foresee every potential interpretation, is it reasonable that everyone should think of species as consumer goods or of their interactions as being like a nuclear power plant catastrophe?

it is also worth noting that we might have foreseen these interpretations. in a certain context, albeit a mistaken one from Hebert's perspective, his metaphor does seem bizarre and Orwellian. Aside from people thinking that species' barcoding might lead to individual humans being barcoded – which h ebert rightly points out makes no sense since 'all we're doing is telling you you're a human' – in a sense the control it seeks over other species is in fact quite Orwellian. It is consistent with our desire to be the Big Brothers of biodiversity (Larson 2007a).

Similarly, people can certainly interpret meltdown differently than Simberloff intends. a s is often the case, however, we can see science-centrism in the evaluation of scientific metaphors: ‘There is no evidence that this hyperbole has impeded scientific understanding or caused loss of scientific credibility’ (Simberloff 2006: 912). He acknowledges, however, that the term meltdown is ‘certainly pejorative’:

> ‘Meltdown’ first appeared in 1965 with reference to nuclear reactors and, in the wake of the Three Mile Island disaster, became increasingly widely used, even metaphorically, to describe processes irreversibly deteriorating, apparently at an accelerating rate – children’s temper tantrums, escalating internet crashes, the 2005 University of Tennessee football team, and the like (Simberloff 2006: 916).

t he fact that the term can be used in all these contexts demonstrates that it can be interpreted in diverse ways consistent with the broader social context in which it occurs. t his is not an argument for using it in science. r ather the opposite. a s Gurevitch (2006: 919) points out, ‘scientists need to be held to a higher standard than the general public in using metaphors and concepts precisely’.

There are deeper stealth policy implications in these metaphors. Nelkin (1994: 27) observes that ‘though the gene in popular culture refers to a biological construct and derives its cultural power from science, its symbolic significance rests less on scientific realities than on social meanings’. Similarly, Hebert’s metaphor is implicitly a political statement because it proposes that we handle and relate to biodiversity in one way as opposed to others (Larson 2007a). It is such conscious or unconscious stealth advocacy, hiding values within scientific statements, which can lead to the discrediting of science and to policy blockage. Hebert stated that ‘I actually would not mind the fact of humanity starting to think of species as important items on the store shelf of life. I mean, I really think that might be a very progressive step from the current view, which is that you can’t read these things at all’. it is arguable whether we should treat species as product lines of life, but the barcoding metaphor brings that perspective in through the back door, beyond ethical scrutiny. While h ebert argues that this perspective could bring recognition to the purpose of non-human species, it is equally possible that it would devalue them. t hey are living beings that have an intrinsic value, in contrast to the instrumentalist view that they are there for mainly our purposes, to meet our needs as ‘product lines of life’. t hey may be ‘lines’ of life, but are they products? in a broader sense, h ebert’s metaphor places biodiversity within a very consumeristic context (Larson, in preparation).

Similarly, a ‘meltdown’ carries various associations and, from my informal discussions with people, most of them are negative. it is apocalyptic with regard to invasive species – they are bad – and it thus advocates on behalf of native ones. The metaphor is used to incite a fear of the consequences of this ‘meltdown’. It draws on a prevalent ‘fear-factor’ approach to invasive species, one that has been drawn into question by other scholars citing empirical social data (Gobster 2005). In this sense, it is ethically suspect in a scientific context because it communicates more than just the facts of the matter. Rather than engaging the reader in open dialogue about the dynamics and consequences of invasive species, it skips to a political statement that invasions are bad. e ven if this is the way some scientists feel, there are problems with framing such political statements and personal values as scientific facts.

As Nelkin observed, promotion is a double-edged sword and scientists must somehow balance its benefits and costs to peers and funding agencies, not to mention the public more generally. Communication is a two-way street (Weber and Word 2001). Accordingly, scientists need to take greater responsibility if they are going to use metaphors to attract attention. t hey cannot arbitrarily raise and lower the bar – with preferred associations of a word being considered ‘scientific’ and others being considered naive and unscientific. m etaphors are by their nature words that operate to break down such boundaries, including the one between science and society (Bono 1990; Larson 2006). Social scholars have repeatedly shown that scientists negotiate this boundary to maintain their authority (g ieryn 1999) and metaphors provide a prime mechanism by which they do so.

In the classic case, often called the ‘linear’ model of science and society (Pielke 2007), scientists create objective knowledge that is then adopted (or not) by people in society ‘downstream’. With the metaphors considered here, however, scientists advocate a particular view themselves, even without the media as an intermediary. t hey are promoting a particular way of approaching or viewing something, which is by its nature ideological; yet they are relying on their scientific authority to do the selling for them. t hey are advancing personal and political views in the guise of scientific language.

t hey also used these metaphors even before their appropriateness had been settled. This might seem unfair, as Hebert, for example, likely felt that he had enough support and his paper was published in a refereed journal. But journals are not above fanfare. Simberloff also appears comfortable working ahead of the evidence, waiting for time to prove him right. a n alternative model for the development of such an idea would be to begin more slowly rather than with such a bang (see Nerlich, this volume). At a later date, when the scientific evidence was nearly incontrovertible, the public communications campaign could have begun. Metaphorically speaking, they could be more muted and increase their volume as the evidence accumulated. But this would require tremendous patience and restraint. In particular, the allure of funding and prestige would make this challenging. Hebert may be correct that the project would never have received the funding it did without the vision and the metaphor that were provided, but could he have waited longer? Perhaps not in a climate where science is conceived, more and more, as a race for funding, breakthroughs and commercial benefits (see Nerlich, this volume).

t here is an additional problem with using metaphors before they are well supported. Like it or not, non-scientists are more likely to take scientific results as hard facts than many scientists. in this context, it is possible that scientists face certain problems that journalists do not. Specifically, biologists appear more likely to take their metaphors as real, as opposed to the journalists who might be aware that they are popularizing. a s these case studies have shown, biologists who coin metaphors seem to have, at some level, really adopted the metaphors they have proposed such that they recognize little distinction between metaphor and reality. While journalists may take more liberties in using novel metaphors, perhaps everyone understands that that is their role; their metaphors are not meant to correspond as closely to reality as those used by scientists. in some cases, scientific metaphors such as the ones discussed here subsequently drive the journalistic response.

Conclusion

How might scientists approach these ethical issues? How might they make decisions about the degree of advocacy to pursue? m etaphors remain with us for a long time once they are activated (see Hellsten, this volume) and it could be decades before we can assess whether their use was appropriate. i suggest that this is all the more reason to take care.

We might imagine two extremes. o n the one hand, scientists could be more objective in decisions about metaphors. By weighing their contextual interpretation, they might forestall potential misinterpretations that could cause people to reject a conception they might otherwise accept. if scientists wish to use such metaphors, they might better rely on the best available knowledge rather than their intuitions (which may be wrong). It is an empirical question whether 'DNA barcoding' leads people to value organisms more or less. It is similarly an empirical question whether a 'meltdown' draws appropriate attention to invasive species.

Rather than conducting that empirical work, as a social scientist might approach it, we see assumptions masquerading as facts. In declining to assess the implications of their metaphors, Simberloff claimed 'i don't have enough expertise in psychology and sociology' and Hebert stated, 'I can't speak for the public'. But they still did so implicitly in deciding to use them. Simberloff, for example, claimed that he 'thought about all the right things', but as we've seen above he saw his metaphor as neither emotional nor controversial. He also acknowledged in the interview that he 'didn't think about' whether he might have set himself up for misinterpretation by using the metaphor he did. Just as we have social processes to assess potential new technologies, perhaps we need the same for metaphors, which instantiate a particular way of relating to the world.

o ne empirical angle would be to explore whether alternative, less expressive metaphors would work. Hebert discounted the alternative expression 'species-specific DNA sequence tags' as 'I'm pretty sure the public would have rolled their eyes up and gone to sleep'. He remarked, 'if we had presented it gently, nothing would have happened … t o me, it's a big success, so therefore we can't have screwed up too badly'. h ebert thereby measures the success of the Dna barcoding project in terms of funding received. In modern science, that has often become the ultimate measure of worth – though others would argue that such an enterprise is not worthy of the name of science. indeed, at one point the u S n ational Science Foundation rejected a funding appeal because DNA barcoding was 'not science'. Such issues merely reveal the extent to which modern science is in the business of fund-raising, with all the related issues of how this might affect objectivity. On the other hand, some scientists might feel that the risk is worth it in the interest of conserving biodiversity.

Simberloff also considered alternatives such as 'positive feedback', which was 'one of a number of boring titles'. Gurevitch (2006: 919) uses another catchy metaphor: 'Runaway positive feedbacks in a system create "snowball" effects in which a phenomenon builds on itself in an accelerating fashion, becoming unstoppable'. We have very little understanding of how people would respond to such alternatives. And even if we did, would a social marketing approach to scientific metaphors be appropriate or even possible (see Larson, in preparation)?

At the other extreme, we can turn in a very different direction than the 'objectivity' usually pursued in both the natural and social sciences. in an insightful essay on humanities and science, Lewis Thomas (1985: 155) suggests that we turn to poets, 'on whose shoulders the future rests'. a t the very least, this might bring humility. We can find some evidence above that these scientists were more committed to what Jasanoff (this volume) called 'technologies of hubris' than to 'technologies of humility'. Hebert, for example, asked, 'How do you present a revolution?' Even with this intention, poets could help. Working with the social scientists alluded to above, poets – and others sensitive to the nuances of our language choices – might help us to coin better metaphors and to foresee where they might lead. t his would lead to a very different form of science, one in which humanities and science were more fully blended and, with them, science and society – allowing each of us a more constructive role in decisions about which metaphors we want to shape our world.

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Chapter 12

m etaphors as t ime Capsules: t heir u ses in the Biosciences and the m edia

iina h ellsten

Introduction

o ur everyday discussions about science and technology are rich in metaphors. Car engines, for example, are described in terms of their *horsepower* and we readily discuss complex techno-scientific issues such as cloning in terms of making photocopies, or stem cell research in terms of whether *harvesting embryos* or *making copies of human beings* is ethically acceptable. a ll three examples are metaphors since they approach one issue (e.g. stem cell research) in terms of another (e.g. harvesting). Yet, what actually links engine power to horses, or cloning to making photocopies and stem cell research to harvesting? What role do such metaphors play at a cultural and societal level and what implications for understanding science do they have?

The conventional definition of a metaphor is that it is a mapping between a source domain (e.g. harvesting) and a target (e.g. stem cell research) domain (e.g. Black 1962; Lakoff and Johnson 1980). Cognitive linguists have largely studied these mappings in terms of 'embodiment', or how we map various experiences we have of our bodies onto our understanding of more abstract issues. t hey have rarely looked at mappings that establish links between past cultural and technological 'experiences' and modern ones. But these kinds of mappings are just as important as those based on our bodies. So, in terms of our examples, we conceptualize 'present' everyday experiences with car engines by using metaphors that map them onto past experiences we, or our ancestors, once had with horses. t his type of mapping occurs commonly in semantic change related to what some semanticists have called 'linguistic conservatism' and what one could also call metaphorical conservatism (see Ullmann 1962: 198). We talk about horse power despite the fact that our cars are no longer drawn by horses and about harvesting stem cells despite the fact that harvesting is no longer a common experience. in fact, it should be stressed that the use of such metaphors does not require us to have any direct experience of horse-drawn carriages or harvesting. t hey all seem to rely on a set of shared 'associated commonplaces' (Black 1962) or ideas concerning the source of a metaphor which are generally thought to be true in a particular culture, a type of cultural 'memory' of the social group that uses the metaphor. it follows, then, that there is a temporal discrepancy (although in the case of copying the distance is less great) *within* each of these metaphors.

t o date, the role of metaphors in bridging technological and cultural experiences of the past with those of the present has not been studied in detail (but see Hellsten 2008). In this chapter, I will argue that metaphors that build upon temporal discrepancies between the past and the present are not rare, and that such metaphors may actually function as important carriers of cultural memory and meaning across generations. t he argument has its roots in previous research into the role of metaphors as tools of communication across the mass media and the sciences, such as the Human Genome Project (HGP) between the 1990s and 2003 (h ellsten 2001; n erlich and h ellsten 2004; h ellsten 2005; h ellsten and n erlich 2008), cloning in the late 1990s (Hellsten 2000) and the subsequent developments in stem cell research in the early 2000s (Leydesdorff and Hellsten 2005).

my results point not only to the popularity of metaphors that build upon temporal discrepancies, but also to systematic differences in *temporal distances* between the source and target domains in journalistic and scientific publications. it seems that in newspaper articles, intended for wide audiences, the temporal distance between the two parts of a metaphor is much wider than in scientific articles intended for specialized, scientific audiences.

The chapter is organized as follows: First, I will briefly define what a metaphor is, or held to be, by most contemporary scholars. i shall then zoom into a selected set of public documents on the hg P, cloning and stem cell research, to show what i mean by 'temporal discrepancies' in popular metaphors of the biosciences. The third section takes the discussion to a more theoretical level, and reflects on the differences in the temporal distances in metaphors used in newspapers and scientific journals against the background of (different) temporal cycles within which the mass media and the sciences operate. in the last section, my aim is to provide concluding remarks on the role and dynamics of temporal metaphors and open up questions for further research.

Metaphors

As indicated above, scholars of metaphor typically define metaphor as a mapping between a source (such as harvest), and a target domain (e.g. stem cell research). in cognitive linguistics, the emphasis has been on the role of metaphors as bridges across normally independent domains of cognition (Lakoff and Johnson 1980). In research into the dynamics of knowledge, by contrast, the focus has been on the role of metaphors as carriers of knowledge across discourses and disciplines (Bono 1990; Väliverronen 1998; Maasen and Weingart 2000). I shall add to this my study of metaphors as bridges across time and social and cultural memory. As history progresses and direct knowledge of a source domain fades away and becomes less familiar, one would expect metaphors to lose communicative power. h owever, the opposite seems to be the case; the longer a word or metaphor is in use the stronger its staying power becomes, even though knowledge of the source domain may be minimal.

Several lines of research have discussed the relation between metaphors and time, which cannot all be reviewed here (see, for example Schön 1967 and t rim 2007). In the history of ideas, for example, the semantic evolution of concepts across long periods of historical time has been studied in terms of the semantic change of specific concepts, such as a 'crisis', from ancient Greek to Latin languages and further to current language use (Koselleck 2006). In the context of the sociology of knowledge, Maasen and Weingart (2000) discuss the evolution of metaphors in terms of specific, discourse-dependent processes in the negotiation and transfer of metaphors from one domain to another. t hese and other approaches have provided valuable insights into the dynamics of cultural evolution with relation to metaphor. h owever, they have not explicitly investigated temporal discrepancies within a metaphor, i.e. between the source and target domains of a metaphor.

Popular metaphors of science and technology

In the media, scientific and technical discoveries are often framed either as sensational breakthroughs and innovations (see Nerlich, this volume), or in terms of steps toward creating new monsters. a lthough such framings seem to contradict each other, they do agree on one crucial point: They are both firmly grounded in the metaphorical assumption that scientific and technological progress can be approached as a movement in space, and in particular that '*scientific and technological progress is a journey*' (Hellsten 2002: 1–3; 133–135). Scientific progress is easily discussed as if it was a journey of discovery reaching territories and new frontiers, thus evoking images of the discovery of America, in a European context, or the settlement of the West in an a merican context (e.g., Domurat Dreger 2000). This scientific journey may either lead to discovering the *language of God* or to *opening Pandora's Box* and creating a new *Frankenstein's monster*. The metaphorical endpoints of the journey are derived from shared religious or mythical commonplaces, from what Nerlich et al. (2003) have called a shared cultural pre-cognition.

The metaphorical narrative of scientific development in time as a journey in space is fruitful, for it provides us with a perspective from which we can better grasp science and technology as a process. In Burke's (1989) words, metaphors help to reduce the complexities of topics since they force us to focus on certain salient aspects. Inevitably, metaphors also keep some aspects of the issue out of our focus. t his reduction of complexity often relies on references to stereotypical narratives which themselves are only briefly sign-posted by a reference to the title of a book, such as Frankenstein or a reference to a myth, such as Prometheus, or, as in m ary Shelley's *Frankenstein or the modern Prometheus* (1918/1994).

Furthermore, specific metaphorical expressions (such as metaphors for the internet as a super-highway or a web) seem to change much faster than the 'deep-structure' of metaphors rooted in shared cultural and religious history and mythology (e.g. Prometheus, Icarus, Pandora's Box). As an example, consider the ongoing influence of the 'book of life' metaphor, which derives from the Judeo-Christian tradition. t he deep, narrative level of metaphors seems to remain remarkably similar over generations while the actual formulations of metaphors may change in just a few years, according to the cultural fashions of the time (e.g. discussing the nervous system in terms of telegraph wires or the human mind in terms of a computer program).

The source domains of (deep) metaphors that use temporal discrepancies may deal with historical events as well as a set of fictional or mythical narratives – but only as long as such events and stories are *expected to be widely shared* by the cultural group that uses these metaphors. t his expectation of a shared set of cultural experiences passed on in stories and myths seems to play a crucial role in making some metaphors more salient than others. At the same time, the metaphors that become popular in a specific cultural group often highlight and reinforce highly selected, dominant views of the past achievements of the group. In this way, popular metaphors are far from innocent figures of speech.

t emporal discrepancies in popular metaphors of science and technology

t he analysis of temporal discrepancies in popular metaphors is rooted in my previous research and builds upon a series of case studies on the role of metaphors in public debates about the biosciences. in this section, i will concentrate on a few examples of popular temporal metaphors that have been used in public debates about the hg P, cloning and stem cell research. i will use a selection of press briefings and similar documents to illustrate in a condensed manner temporal discrepancies in metaphors and to contrast the temporal distances of metaphors used in bioscience and in the mass media (more in-depth studies can be found in h ellsten and n erlich 2008; n erlich et al. 2002; n erlich and Dingwall 2003; Nerlich and Hellsten 2004, for example).

While the debate over the hg P illustrates how metaphors can be used to glorify the biosciences, the debates over cloning and stem-cell research illustrate how metaphors can be used to reflect public fears about advances in the biosciences.

The Human Genome Project

The HGP was launched in the 1980s and by the year 2000 a first draft of the human genome was achieved. t his event was widely reported as a triumph in 'decoding' the human genome, a metaphor that initially tied in directly with experience in the, then novel, technology of information, but which over the years became conventionalized. Popular metaphors of *genes as codes, blueprints* and *maps* have become central to the development of the sciences of genetics and genomics themselves. t he code metaphor in particular was created in the

1950s, at a time when the theory of information was in vogue, to understand the object of the new science of gene sequencing and to communicate it to public. Condit (1999) even argues that '[t]he new discoveries of molecular genetics were at first not communicable to the public. Science was mute in the public sphere until it formulated the coding metaphor.' t his historical baggage carried by the code metaphor is normally forgotten in modern scientific discourse but can be foregrounded when trying to celebrate the achievements of the hg P in terms of 'decoding' the book of life or the language of God. This was skillfully done both by politicians and the media in the year 2000, when a first draft of the human genome was achieved, a result that was widely reported as a triumph.

The metaphor of the genome as a 'book' (of life) is both novel and old. The source domain of *the book of life* refers to natural, eternal and universal texts (Kay 2000: 31). In the Bible, the names of those to be saved after the apocalypse are written in the '*book of life*'. Furthermore, books in general carry historical connotations associated with the invention of the printing press by g utenberg, as well as with Galileo, who wanted to decipher the book of nature. Books, in turn, are printed using the letters of the alphabet, which again is an ancient invention of immense historical significance.

The connection between cellular systems and the alphabet first became popular in the 1960s when molecular biologists started using the metaphor for understanding the workings of DNA (van Dijck 1998: 123). This was coincident with the discovery that Dna is composed of four nucleotides, which were represented by their initial letters, A (adenine), T (thymine), C (cytosine) and G (guanine). A, T, C and g became *the alphabet of life.* m etaphors of decoding, reading or deciphering both the book and the alphabet of life were effectively used to promote the HGP to the public, and ever new formulations of it are now used to promote post-genomic research (for more novel developments see Balmer and Herreman, this volume), alongside the search for more novel metaphors (see Turney, this volume), which, however, still have to prove their temporal staying power.

t he use of such metaphors reached a climax on 26 June 26 2000, when a group of scientists and politicians[1] announced in a fanfare of publicity that the human genome was nearly mapped. In the press briefing, President Clinton declared:

> Nearly two centuries ago, in this room, on this floor, Thomas Jefferson and a trusted aide spread out a *magnificent map* -- a map Jefferson had long prayed he would get to see in his lifetime. t he aide was m eriwether l ewis and the map was the product of his courageous *expedition across the American frontier*, all the way to the Pacific. It was *a map* that defined the contours and forever expanded the *frontiers* of our continent and our imagination.

1 Bill Clinton, the then President of the United States held a press briefing at the White House flanked by the leaders of the two (competing) US human genome projects, Dr. Craig Venter and Dr. Francis Collins. They were joined via satellite link from London by t ony Blair, the Prime m inister of the u nited Kingdom.

> […] a fter all, when g alileo discovered he could use the tools of mathematics and mechanics to understand the motion of celestial bodies, he felt, in the words of one eminent researcher, 'that he had learned the *language in which God created the universe*.
>
> t oday, we are learning the language in which g od created life. We are gaining ever more awe for the complexity, the beauty, the wonder of g od's most divine and sacred gift. With this profound new knowledge, humankind is on the verge of gaining immense, new power to heal (White House Briefing Room 2000, my emphasis).

This speech compares the (near) completion of genome mapping to past accomplishments, such as conquering and mapping of the American frontier and g alileo's revolutionary inventions in mechanics. Clinton seems to expect that the audience will share a feeling of pride in the previous moments of 'glory': conquering the American frontier and the Galilean revolution. The metaphors carefully play with what is expected to be shared by the members of the audience (such as the emotions associated with conquering new frontiers, the religious feelings associated with g od, and the commonly accepted idea that the g alilean revolution was something 'good' and 'progressive'). In this context, the speech suggests that the near completion of the hg P is a similar moment of 'cultural' glory. t he metaphors thus function at the level of cultural groups instead of individual cognition as argued by Lakoff and Johnson (1980).

The metaphors hide alternative feelings about conquering the American frontier in terms of the genocide of indians and destruction of natural ecosystems and their species and thereby serve to strengthen dominant views of shared cultural pasts, effectively consolidating the histories of the dominant group. t hey also hide the senses in which the hg P differs from cartography and mechanics, how new knowledge in science differs from conquering geographical areas, especially since much of that knowledge is still not completely settled, uncertainties and ambiguities remain and new gaps in knowledge have actually opened up for further investigation.

t hese were the dominant metaphors used to celebrate the near completion of the hg P, but there were also alternatives. t he h uman g enome r esearch institute, for example, published a press release that approached the event from a different angle, and used different metaphors in its efforts to make the achievement more comprehensible to the public. t he institute declared that:

> The Human Genome Project (HGP) public consortium today announced that it has *assembled a working draft* of the sequence of the human genome – the *genetic blueprint* for a human being. This major milestone involved two tasks: placing large fragments of DNA in the proper order to cover all of the human chromosomes, and determining the DNA sequence of these fragments. t he *assembly* reported today consists of overlapping fragments covering 97 percent of the human genome, of which sequence has already been assembled

> for approximately 85 percent of the genome. The sequence has been threaded together into a string of a s, t s, Cs, and g s arrayed along the length of the human chromosomes. *Production of genome sequence* has skyrocketed over the past year, with more than 60 percent of the sequence having been produced in the past six months alone. During this time, the consortium has been producing 1000 bases a second of raw sequence – *7 days a week, 24 hours a day* (n ational Human Genome Research Center 2000, my emphasis).

instead of placing the achievement in the context of previous emotional moments of glory, the institute used metaphors that emphasize genome mapping as a milestone in the overall progress of science, with the endpoint being assembly of a working draft–rather than a definite version of a the book of life. Most importantly, sequencing of the human genome is compared to a factory assembly-line in which the mass production of goods goes on around the clock, 7 days a week, 24 hours a day.

t he audience is expected to share a view of industrialization as modernization and as 'progress' that has led to 'common goods' in the form of (material) welfare. This expectation may hide alternative views on industrialization by making such alternatives unthinkable, or at least very difficult to speak about. The metaphor of mass production is rooted in experiences of factory work that have little in common with current experiences of office work, but nevertheless the image is appealing. It should be stressed however that both the metaphor of mass production and that of the glorious conquering of new frontiers function as bridges across a selected view of the shared past and present of a social group. t he metaphors of industrialization as a common good and of conquering the American frontier may strengthen dominant views of colonialization and industrialization as self-evidently good developments. in other words, they strengthen the dominant views of the historical past. in an article entitled 'The Sociable Gene', Turney (2005, and this volume) has reflected on the growing mismatch between the scientific understanding of the gene and its popular metaphorical representations. This mismatch has ethical consequences for science communication, as some metaphors may perpetuate hopes and promises or else fears and dangers which are no longer the current ones.

Cloning and stem cell research

in contrast to the positive and glorifying metaphorical framing surrounding the HGP, developments in cloning and in stem cell research provoked darker metaphors, where the journey of science was conceptualized as leading not so much to the pot of gold at the end of the rainbow but rather to a monstrous underworld.

t he successful cloning of a sheep from an adult mammalian cell was brought to public attention at the end of February 1997, when the r oslin institute in Scotland introduced Dolly. Media attention was immense and was intensified by an article published by *The Observer* ahead of the official announcement (for more information on this 'scoop', see Wilkie and Graham 2001: 138). The cloning of a sheep readily evoked a set of associations and cultural narratives of 'copying humans' that were widely shared by large groups of people familiar with popular science fiction books, such as Aldous Huxley's *Brave New World*, and ira l evin's *The Boys from Brazil*.

For a previous case study on cloning (Hellsten 2000), I conducted a systematic comparison of how metaphors such as 'clones are mass products' and 'science is a journey' were used in *Nature* and in *The Times* in 1997. in *The Times* the metaphor of clones as mass products was used in the sense of producing 'lousy copies', while in *Nature* the same metaphor referred to 'perfect products'. *The Times* wrote about the production of carbon-copy people, a process that would reduce genetic variation and lead to the elimination of genius, for example, as 'the essence of genius is originality: a copy would never be more than an imitation' (a noymous 1997a), while *Nature* stressed that cloning could be used to 'generate skin grafts for burn victims, or other spare-part provision', or to produce perfect organs and to provide cheaper medicine for certain illnesses such as cystic fibrosis and sickle-cell anaemia (Wadman 1997: 204). Here, cloning was compared to the creation of good, useful products instead of cheap imitations. Significantly, in *Nature* cloning is connected to the discourse of hope while in *The Times* it is associated with the discourse of fear. Progress in cloning can be metaphorically conceptualized in two ways. Scientific action can be related to controlled upward progress which includes overcoming barriers, or it can be related to an apocalyptic downwards path. in *Nature,* John Porter from the h ouse of r epresentatives noted 'cloning itself can lead to a great deal of progress in science' (Wadman 1997), whereas *The Sunday Times* on the other hand warns that when scientists engage in cloning it is as if 'the hand of God has been grabbed by a figure in a white lab coat and shoved to one side' (Anonymous 1997b).

in summary, both in *The Times* and in *Nature* cloning was discussed as assembly-line production of identical creatures, but the reason for using the metaphor of cloning as mass production varied. t his metaphor of factory mass production was also used in the hg P case above. interestingly, in *Nature,* the temporal distance between the source and the target domain is relatively short (clones are conceived as perfect products, digital copies one could say), whereas in the newspaper the distance between source and target is wider (clones are carbon-copies). But, what did the original press release by the r oslin institute say?

o n 24 February 1997, the r oslin institute published a press release, entitled *'Scientists at the Roslin Institute Publish Scientific Breakthrough*'.

> t he r oslin institute and PPl t herapeutics have published in *Nature* the successful breeding of cloned sheep through nuclear transfer from differentiated foetal and adult cells. t his is a *major breakthrough* as it is the first time that any mammal has been derived from foetal or adult cells…
>
> t he new nuclear transfer technology will allow transgenic *animals to be produced more cheaply.* Genetic modification of the donor cells in culture before they are used in nuclear transfer will also allow us to introduce very precise

> changes in their Dna and open up possibilities for a range of new products for the treatment of, for example, cancer and inflammation', said Dr. Wilmut (my emphasis).

The press release and the subsequent press coverage led to a heated debate about the ethics of cloning. For the sciences, cloning seemed like a way to produce perfect transgenic animals at lower costs for medical research and future treatments, while for the mass media, the development was a first step towards cloning living creatures as mere mass products (Hellsten 2000).

in m arch 1997, President Bill Clinton banned federally funded research into human cloning in the u S. t his was probably mainly because the aim or end of science's journey was framed differently in the mass media, not as creating transgenic animals for medical purposes but as creating hordes of carbon-copy humans, if not hordes of Frankensteinian mutants and replicants.

t he successful cloning of a mammal from adult cells enhanced research into stem cells, and laid the foundations for the discovery of how to isolate stem cells from human embryos. t he stem cell debate, from the very beginning, applied many of the same metaphors that were previously used in the debate about cloning, including references to 'playing g od', 'opening Pandora's box' and creating monsters and monstrous spare-parts.

Stem cells play an important role both in embryonic development (embryonic stem cells) and the renewal of adult tissues (adult or somatic stem cells), and they can differentiate into various types of cells, such as blood, brain and bone cells. Stem cells, therefore, seem to open up new treatments for diseases that are caused by cell damage in one organ, such as a lzheimer's disease, multiple sclerosis, and various types of cancer. Stem cell research, in particular embryonic stem cell research, has gained widespread public attention since the late 1990s, mainly because of the ethical implications of using human embryos in the production process, but also because of the promises for effective treatment of common diseases. a nti-stem cell campaigners made a connection between aborted embryos and stem cell research, hence raising the highly disputed topic of abortion.

In 1999, the American Association for the Advancement of Science (AAAS) and the institute for Civil Society published a report on stem cell research (Chapman et al. 1999). The report recommended further funding for stem-cell research mainly because of its great potential for treatments, and set up certain conditions for the research, e.g. that only excess embryos from infertility treatments, with explicit consent of the donors, can be used in research.

t wo years later, however, President g eorge W. Bush Jr. prohibited federal funding for most embryonic stem-cell research in the u .S. because of its ethical implications. o n a ugust 2001, he declared in a televised speech:

> t he u nited States has a long and proud record of *leading the world toward advances* in science and medicine that improve human life. a nd the u nited States has a long and proud record of upholding the highest standards of ethics

> as we *expand the limits of science and knowledge*. r esearch on embryonic stem cells raises profound ethical questions, because extracting the stem cell destroys the embryo, and thus destroys its potential for life. Like a *snowflake,* each of these embryos is unique, with the unique genetic potential of an individual human being.
>
> As I thought through this issue, I kept returning to two fundamental questions: First, are these frozen embryos human life, and therefore, something precious to be protected? a nd second, if they're going to be destroyed anyway, shouldn't they be used for a greater good, for research that has the potential to save and improve other lives?
>
> (…) I strongly oppose human cloning, as do most Americans. We recoil at the idea of *growing human beings for spare body parts*, or creating life for our convenience. a nd while we must devote enormous energy to *conquering disease*, it is equally important that we pay attention to the moral concerns raised by the *new frontier of human embryo stem cell research. Even the most noble ends do not justify any means.*
>
> (…) I also believe human life is a sacred *gift from our Creator*. i worry about a culture that devalues life, and believe as your President i have an important obligation to foster and encourage respect for life in a merica and throughout the world. a nd while we're all hopeful about the potential of this research, no one can be certain that the science will live up to the hope it has generated. (t he White House 2001) [my emphasis].

Cloning is here approached as potentially leading to mass production of body parts – mostly in the way that had previously been discussed in the mass media, i.e. embryonic stem cell research was considered as a new frontier of research that may degrade human beings to mere mass products.

in summary, the public speeches and press releases around the hg P and cloning/stem cell research point to a considerable temporal gaps between the source and the target domains in popular metaphors. in both cases, public announcements by leading politicians and scientists were aimed at wide audiences, and the metaphors used relied on a set of cultural commonplaces (e.g. glorious colonisation of America; spectacular industrialisation etc.) expected to be shared by most of the members of the wide audience and linked in one way or the other to the journey metaphor.

In the next section, I wish to take a look at the different types of audiences that were expected to receive such metaphorically framed announcements, and discuss how this may affect the temporal distances in the popular metaphors used. Based on my earlier case studies, my hypothesis is that the temporal distance between the source and target domain of most of the popular metaphors of science and technology is different in journalistic and scientific publications. In particular, I argue that this 'distance' is wider in journalistic accounts than in scientific publications.

Differences between the cycles in sciences and the mass media

Those who use metaphors for communication have an implicit expectation of what knowledge particular audiences share and thus how they will respond, i.e. about what aspects of the source domain are mapped onto the target domain and how the metaphor will be further interpreted and re-formulated.

The cycles of practice in the sciences and in the news media differ in three main ways (Luhmann 2000; Leydesdorff 2001). First, the cycle of communicating in the sciences has traditionally been slower (from four times a year journal issues to a weekly publication as in the case of *Nature*) than in the mass media (from hourly updates to a daily cycle). This seems to be changing both for scientific publications and news publication because of the new digital, Web-based publishing. Second, the sciences aim to publish new insights while the mass media need to keep an eye on what is likely to be familiar to its audiences. Third, this relates to the expected audience of scientific publications (quantitatively restricted, but with deep knowledge on the issue) and that of the mass media (wide audience with shallow knowledge). Hence, the mass media often relies on common myths and commonplaces in their use of metaphors while the sciences seem to be more rapid in updating the source domains of their metaphors (e.g. clones as digital copies in the sciences versus clones as carbon-copies in the mass media).

What role do these three differences between the cycles of the sciences and the mass media play in the temporal distances in metaphors used in biosiences and in the mass media? Luhmann (e.g. 2000) has provided communication sciences with the hypothesis that social systems in society (such as the sciences, economics and politics) are functionally differentiated systems that have their own logics of action, use their own codes of communication, and have their own cycles of action. Drawing an analogy between biological and social evolution, Luhmann (2000) defined social systems as self-organizing and self-referential. Systems operate in terms of simple codes, such as power (political system), money (economic system), truth (scientific system) and information (the mass media). The use of a simple code of communication reduces the complexity within each system to a level that allows them to operate (Leydesdorff and van den Besselaar 1997). The aim of the systems is to maintain their own operation. For example, the goal of scientific action is to produce new uncertainties and further research questions, while the goal of the mass media is to produce news. Functional differentiation has also led to different temporal cycles of action.

With respect to metaphors, it may be hypothesized that the deep narrative level changes more slowly than actual linguistic expressions (Hellsten 2002). In addition, deep narratives seem to change more slowly in journalistic discourses than in scientific discourses (van Dijck 1998). Journalistic stories have to resonate with existing frames and narratives, whereas scientific discourses (at least those published in scientific journals) are supposed to continuously open up new perspectives on research topics.

t he differences in the codes, the logics of action and the cycles of action all have a bearing upon the use of metaphors. o n one hand, metaphors may provide continuity between the codes of truth and information, the code of the sciences and the code of the mass media. For instance, the metaphor of 'science as a journey' offers a common ground that interests both the sciences and the mass media. o n the other hand, the different systems may perceive the (future-oriented) goals of the journey differently due to their different codes, logics and cycles of action. An upwards journey of progress may be preferred in scientific writing, a downward journey of alarm and fear may be preferred in the mass media.

Discussion

in general, many of the popular metaphors used to communicate about the biosciences seem to function as cultural carriers of a dominant version of a shared cultural past, which is often disconnected from present activities and experiences of the group. The metaphorical frame of scientific and technological progress as a journey is fruitful precisely because it is so general, and allows for a rich set of possible interpretations, uses and further formulations. t he metaphor of 'science as a journey' opens up a common ground both to discussing developments in terms of mapping and conquering unknown frontiers of knowledge and gaining control over diseases and life itself, and in terms of the risks involved in crossing new frontiers and going beyond known territories and entering danger-zones.

The politics of metaphors (Hellsten 2002) is based on exploiting the ambiguity of the potential uses of the metaphor. For example, deep metaphors, such as '*science's progress is a journey*' or '*cloning and stem cell research are assembly-line mass production*' imply 'tacit' knowledge about a specific set of characters associated with a journey (linearity, conquering, mastering something) and industrialization (mass-production, assembly-lines, wealth). The set of elements that is expected to be widely shared is a very limited, selected set of associations which is expected to strengthen the mainstream views of the past held by a group, and may shut off a set of alternative pasts.

Further formulations of metaphors differ across various discourses. t he source domain of the metaphor of 'science as a journey' exploited by the mass media is not based on current experiences of journeys by airplane, for instance, but on much older and more stereotypical images of conquistadors and colonialization. Or, alternatively, scientific results are represented as 'dangerous' activities, the results of which have been described in ancient Greek myths (Pandora's Box, Prometheus, Icarus etc.), or more recent novels (*Frankenstein, Brave New World*). In this sense, our popular metaphors of science and technology work by establishing bridges between culturally shared ideas of the past (held by a dominant group) to that of culturally preferred views of the present held by that social group (trying to be adopted by another group).

The metaphors of the book of life and mass production, for instance, have long and established histories, and therefore they provide familiar ground for debates. t hese metaphors provide resonance between familiar and new situations, and carry positive connotations of scientific and technological progress over from Gutenberg and g erald Ford to modern science. m etaphors which are deeply embedded in our thinking and talking might perpetuate ideas, values and attitudes which, from the point of view of science, are outdated. As stated by van Dijck (1998: 198), ‘Common sense tells us that imagination is always ahead of technology, and that our technological tools keep lagging behind. However, in the context of genomics, the opposite might be more accurate: our imaginative tools can hardly keep up with our technological innovations’.

in conclusion, popular metaphors that build upon temporal discrepancies between the source and target domains may be important tools for carrying a set of historical memories and common places from one generation to another, but they also carry with them cultural prejudices and preconceptions and should therefore also be studied for their ethical implications. in addition, the space in which the source domains of the popular metaphors are updated differs across social systems. t he mass media often relies on more distant source domains compared to the sciences, and the daily cycle of action in the mass media is generally faster than in the sciences. Such (unintended) discrepancies may further enhance miscommunications between the sciences and the mass media.

Conclusion

In this chapter, I have tried to sketch out some, but by no means all, dimensions of a very complex interaction between metaphor and time and between metaphor, science and the media. Firstly, science as a process over time is often conceptualized as a movement across space, using the metaphor of a journey. Secondly, the end points of this journey can be seen as good or bad, as an upward movement of progress or a downward one of danger or disaster. t hirdly, metaphors for the process of science can involve time at various degrees of depth, when talking for example of harvesting stem cells (greater temporal distance), assembling (slightly closer temporal distance), decoding the genome or copying genes (even closer temporal distance) and so on. Fourthly, metaphors for the products of the journey can also involve time at various degrees of depth, when talking about opening Pandora’s box (great temporal distance), creating Frankensteinian monsters (slightly closer temporal distance) or carbon copies (closer temporal distance). t hese metaphors for the process and products of science involving the exploitation of various temporal distances seem to be used with different preferences in science publications and as compared to political announcements and the media. g enerally, political announcements and media representations seem to rely on what one might call more conservative metaphors relying on linking technologies or procedures or myths from the distant past to the present, whereas science publications seem to exploit metaphors involving shorter temporal distances and they even try out some entirely novel metaphors. And finally, I have tried to hint at some of the ethical implications that the use of metaphors as time capsules can have, as they may carry over from previous generations prejudices preconceptions and ethically dubious practices, such as conquest and exploitation. Metaphors as time capsules provide a rich source of data for researchers interested in dynamics of discourses over time, or what Foucault (1972) called the archaeology of knowledge. There is need for further research into temporal distances in metaphors, and the ethical and sociological implications of such temporal discrepancies.

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Chapter 13
Breakthroughs and Disasters: The (Ethical) Use of Future-Oriented m etaphors in Science Communication

Brigitte n erlich

Introduction

In his recent book, *The Carbon Age*, e ric r oston claimed that:

> Knowledge emerges only in dialogue and only with evidence. if a scientist doesn't find flaws in his or her own work, someone else very well may. Science is structured, ideally, to keep everything transparent and everybody honest (Roston 2008: 52).

a s r oston says, 'ideally' science is structured in an honest and transparent way. a nd ideally science communication should also be as transparent and honest as possible. But this ideal state is threatened as soon as science comes into contact with politics, be it national politics, international politics or the politics of science funding. 'Realpolitik' has always come into conflict with science's ideal state, as well as ideals of science communication, but perhaps now more so than ever.

a s Bernard Schiele recently pointed out in an interview 'Sciences today are increasingly subject to the need to produce innovative developments, as these are needed to maintain a level of output or commercial production.' a t the same time there are, as he points out, 'changes in the profession of journalists, who must now make their mark within an economic structure that is integrated and globalised as never before' (d'Hoop 2008: 8). In the process of producing and communicating 'innovative developments', scientists and science communicators have to engage in what one might call 'expectation management'. t his is something that a number of sociologists in the new field of the Sociology of Expectations have studied, especially with relation to biotechnology. Future expectations and promises are crucial to providing the dynamism and momentum upon which so many ventures in science and technology depend (see Brown and m ichael 2003; Brown et al. 2006) and this is also true for science communication (see Radford, this volume). o ne of the proponents of the sociology of expectations, a rie r ip, has pointed out that:

> e xpectations are part and parcel of regular sociology, but we will argue that they deserve special attention. e xpectations circulate, get articulated, are available as part of a repertoire and become embodied. a s such they are an important feature of modern societies. t hey go deeper than either simple role expectations or cognitive estimates of future happenings. t he future is made co-present through expectations (without losing its prospective, unachieved character) and guides present action and interaction (Rip 2006: 1).

t hus far, the sociology of expectations has mainly addressed the creation of positive expectations, early promises and hopes in fields such as biotechnology and nanotechnology (Brown 2003; Nerlich 2008a). More recently, I have begun to study the impact of negative expectations, early warnings and fears surrounding pandemic influenza, using insights from pragmatics and metaphor analysis and focusing more explicitly on the interaction between scientists and the media (Nerlich and Halliday 2007).

Those who study expectations from a marketing perspective also investigate hype/hope-disillusionment cycles (see Gartner 2006), in which a technology goes through a number of stages characterised initially by high visibility but unrealistic expectations (the 'Peak of Inflated Expectations'), through a period of disillusionment (the 'Trough of Disillusionment'), to a phase of more realistic development. With respect to negative expectations i have examined hype/doom-panic-cynicism cycles. in both cases, with regard to the creation of positive and negative expectations, hopes and fears, metaphors have been used as successful framing devices. But relevant questions include: Is there a better way to orient future behaviour and future funding for science than generating hyped-up promises and warnings (see Larson, this volume)? Is it ethical to hype up promises or warnings? What are the political, or indeed practical, motivations behind such linguistic activities by scientists and science communicators and what are the social and financial consequences?

in this chapter i will explore how 'acts of communication' by scientists and science communicators are linked to 'acts of expectation management' via the use of metaphors. The first section will explore the use of breakthrough metaphors during a time when the positive expectations invested in stem cell research were generating immense pressure for scientists to achieve advances in therapeutic cloning. In the case of Woo-Suk Hwang, this kind of intense pressure came directly from the South Korean government, who wanted Korean stem cell research to win the race for a breakthrough and put South Korea on the scientific map. In the second section of the article, i will explore the use of disaster metaphors to create negative expectations and place pressure on governments. in this instance, i focus on r ichard James at the u niversity of n ottingham, who used images of the apocalypse to scare u K funding agencies into increasing funding for research into the rise of antibiotic resistance and the spread of superbugs such as mr Sa (m ethicillin resistant *Staphylococcus aureus*) (see Nerlich 2008b).

t he two case studies are based on an analysis of metaphors used in u K press coverage between 2005 and 2007.

t he politics and ethics of breakthrough metaphors: t he case of Woo-Suk h wang

i begin by exploring the political and ethical implications of the use of two metaphors, one in which science is conceptualised as a race and the other where scientific advances are portrayed as breakthroughs. Both these metaphors are endemic in science communication and are used almost unconsciously when reporting on advances in science. I will explore them by looking more closely at the press coverage reporting the rise and fall of one scientist, Woo-Suk Hwang, whose scientific claims regarding embryonic stem cells and therapeutic cloning were first reported as breakthroughs but later revealed to be fraudulent. e mbryonic stem cells are:

> the master cells that can be extracted from early embryos, [and] are naturally destined to become all of the cells of the body, a property called pluripotency. […] e xploiting a method called nuclear transfer [used in 'cloning'], which has worked in the mouse but has yet to succeed in humans, scientists hope to create customized patient-specific embryonic stem cells by inserting a patient's skin cells into the milieu of an egg whose own Dna has been removed. (h erold 2007: xiv)

t his is also called therapeutic cloning or somatic cell nuclear transfer as opposed to reproductive cloning which produced, for example, Dolly the sheep.

Since about 2001, embryonic stem cells have been in the news and provoked controversy around the world. m uch hope is pinned on their therapeutic use to alleviate conditions such as Alzheimer's or spinal cord injuries, but much alarm surrounds their creation and the potential to offend various ethical, moral or religious standards related to the status of the embryo (Sandel 2004). However, in the u K and South Korea, hopes for treatment derived from research into therapeutic cloning have outweighed ethical fears on a government level.

> So the expectations on the part of doctors and patients, and the government and commercial pressures on scientists working in this field are enormous. The pressure from the South Korean government – determined to be right at the forefront of technological and scientific innovation – for some dramatic pay-off, was extreme. (Jardine 2006)

Between 2004 and 2005, two teams of scientists, one team working in Newscastle (UK) and the other in Seoul, South Korea were engaged in a race to meet expectations regarding therapeutic cloning. a lthough some researchers later objected to seeing stem cell research as a race, a race it was:

> Stem Cell technology should not be a race - we have to get it right! (Professor Colin McGuckin, Professor of Regenerative Medicine, Stem Cell Institute, Newcastle University)

> This is not about who will be first to 'win the stem cell race' (David Macauley, Chief Executive, UK Stem Cell Foundation) (Science Media Centre 2006)

a lison m urdoch, the leader of the British team, said afterwards in interview with the BBC:

> I don't think it's particularly helpful to think of this as actually a race between scientists to achieve the end because what really matters is making sure that the technologies will get there to give treatments to people, in the long run, and of course stem cell science as such is a much larger thing than nuclear transfer - this is only a very small part of it. (Watts 2006)

In the following, I shall first provide an overview of why race and breakthrough metaphors are, or have become, so important in science. I will then briefly summarise some of the 'milestones' that h wang achieved in this race, before coming back to a take a closer look at the UK press coverage of this race for success.

Conceptualising science as a race has a long history, rooted in 19th century progress in the natural sciences. One can, for example, think of the 'race' between James Dewar and Heike Kammerlingh Onnes to liquify helium, one of the early achievements of low-temperature physics, or the race for Bose-e instein condensation, which began in the 19th century and is still going on today (Capri 2007). a s h ub Zwart has pointed out, in his chapter on 'Professional ethics and scholarly communication', James Watson, one of the discoverers of DNA, unequivocally advocates the idea of science as a race (Zwart 2005: 71). Seeing scientific advances as breakthroughs, however, seems to be a more recent perspective. The term 'breakthrough' first established itself in military usage during the First World War, where it meant 'an advance penetrating a defensive line'. it was only applied to science and technology in 1958, when, in connection with the H-bomb, it took on its current meaning of 'a significant advance in knowledge, achievement, etc.; a development or discovery that removes an obstacle to progress.' t he *Oxford English Dictionary* cites the 11 September 1958 edition of the *Listener,* which hailed 'the technological break-through which allowed both the United States and the u .S.S.r . to produce h -bombs within a year of each other' (*Oxford English Dictionary*, online). Since then, the breakthrough metaphor has become probably the 'most powerfully future oriented metaphor within the current disclosure repertoire of science and science journalism' (Brown 2000: 89).

Since the middle of the 20th century, science has become increasingly political and politicised. But increases in political gain have been accompanied by increases in ethical risks, including increased pressure to get results at any costs, coercion of subjects, falsification of data, and fraud. In contrast to another frame for the activity of science, based on the more neutral metaphor of science as a journey, many components of the 'race' frame carry ethical risks. A race involves competition, even battle, between individuals or teams of individuals; it also involves a prize and therefore has winners and losers. a s early as 21 m ay 2005, the *Guardian* noted that in the 'race for success' in therapeutic cloning 'progress [is] so rapid that it threatens to overwhelm the social constraints that govern such research' (see also Radford, this volume).

The race between the British and South Korean teams took place between February 2004 and December 2005. The 'finish line' was the derivation of stem cell lines from cloned human embryos and the prize was scientific glory. As in all races there was pressure to win – in the case of h wang the pressure from the state was intense, based on 'Seoul's traditional meritocratic pressure thanks to its no-time-to-lose drive for success, amidst rising pride' (Cheow 2006). As one commentator observed on 11 January 2006, after the race was over: 't here was this desire to move ahead rapidly, and h wang was supposed to be the person to pull this cart' (Herbert Gottweis, quoted in Sang-Hun 2006).

in the 12 m arch 2004 issue of *Science*, h wang and his team of researchers at the Seoul n ational u niversity in South Korea announced that they had successfully created an embryonic stem cell line using somatic cell nuclear transfer. t his fulfilled the expectations created by supporters of therapeutic cloning research and put h wang 'at the forefront' of international research. in another paper published in *Science* on 17 June 2005, they announced that they had created 11 new lines of cloned human embryonic stem cells, including, for the first time, two that were genetically matched to patients with a disease. This work was instantly hailed as a 'breakthrough' in biotechnology. Finally, on 3 August 2005, Hwang announced that his team had become the first to successfully clone a dog. The dog, an a fghan h ound, was named Snuppy, short for Seoul n ational u niversity Puppy. a s *The Guardian* (4 August 2005) reported: 'The breakthrough ends a seven-year worldwide race to replicate a dog'.

in o ctober 2005 the World Stem Cell h ub opened in Seoul, South Korea. Eve Herold, the author of the recent book *Stem Cell Wars*, was there at the very moment h wang reached what she calls the 'apex' of fame and put Seoul at the 'epicentre' of stem cell research. We see h wang almost literally standing on the shoulders of giants and reaching for science's highest goal:

> i was touched by the unadulterated hope and optimism that was so palpable at this event. Koreans regarded the opening of their international center of collaboration as a landmark event for their country. Dr. Hwang's work, and the support of the hub, opened up a whole new chapter in their history, placing South Koreans at the proud center of world events. a fter a brief introduction by the director of the newly created Seoul Central Stem Cell Bank, Dr Jung-Gi Im, a video tribute placing Dr. Hwang's discoveries at the apex of modern scientific achievements began. It featured the first flights of the Wright brothers, Alexander Fleming's discovery

> of penicillin, and e instein's discovery of the laws of relativity, followed by the Koreans' milestones in therapeutic cloning. it described the World Stem Cell h ub as the 'epicentre of world stem cell research.' images of Christopher r eeve and Mohammad Ali were followed by a glorious finale with smiling, happy children, blue skies, and messages of hope. (Herold 2007: 166)

As Herold points out, no scientist in recent history had enjoyed such star status and treatment and at no point in history had expectations for treatments using embryonic stem cells been so high. But soon afterwards, in n ovember 2005, g erald Schatten, a University of Pittsburgh researcher who had worked with Hwang for two years, announced that he had ceased his collaboration with h wang because he had concerns regarding oocyte donations in h wang's research as reported in 2004. t here were rumours that some women had been coerced into donating eggs. o n 29 December 2005, Seoul n ational u niversity determined that all 11 of h wang's stem cell lines were fabricated. o n 10 January 2006, the university announced that h wang's 2004 and 2005 papers in *Science* were both fabricated. Following confirmation of scientific misconduct, on 11 January 2006, *Science* retracted both of h wang's papers on unconditional terms. h wang was dismissed from his post at the university in m arch 2006 and in m ay charged with fraud and embezzlement. t oday, he continues working with a private company and now specialises in cloning dogs.

This rise and fall was remarkable but it was also alarming. It exposed cracks in the culture of science, particularly the culture of peer review and the dissemination of scientific results through official journals. But it also called into question the growing practice of 'pre-publishing' results through press releases and public lectures promoting specific research, changes which had been happening for some time but had gone relatively unnoticed. o ne side effect was to undermine the prototypical image of scientists as people of integrity searching for the 'truth'. a lthough there have always been individual scientists who were not above falsifying evidence in order to claim an important scientific 'breakthrough' (Martinson et al. 2005, Radnofsky 2007), the temptation to do so has increased enormously over the last 50 years as the relationship between science, politics and the public has become more and more entangled (Weingart 2006).

How were this race and the final disgrace of Hwang conceptualised in the UK media? To answer this question, Lexis Nexis Professional was used to search UK national newspapers for the key word 'Woo-Suk Hwang' between 1 February 2004 and 12 January 2006. 80 articles were collected and examined and the relevant metaphors were extracted. u ntil the middle of December 2005, a cluster of forward-looking or 'ascent' metaphors was used, whereas metaphors used from the middle of December 2005 until 12 January 2006 (when *Science* retracted Hwang's papers) clustered around images of 'descent'. Figures 13.1 and 13.2 represent how often metaphors relating to scientific progress and scientific setbacks were used in the two small corpora.

Both ascent and descent metaphors frame the progress of science with regard to the broader 'race' or 'journey' frame discussed above. The metaphors therefore

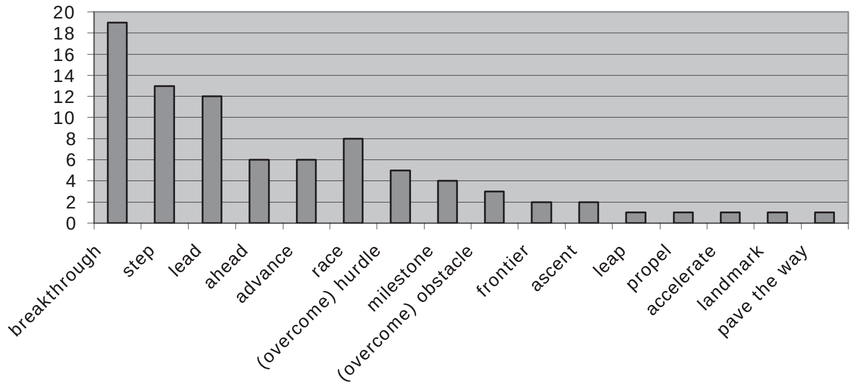

figure 13.1 'ascent' metaphors found in UK national newspapers (1/02/04–15/12/05)

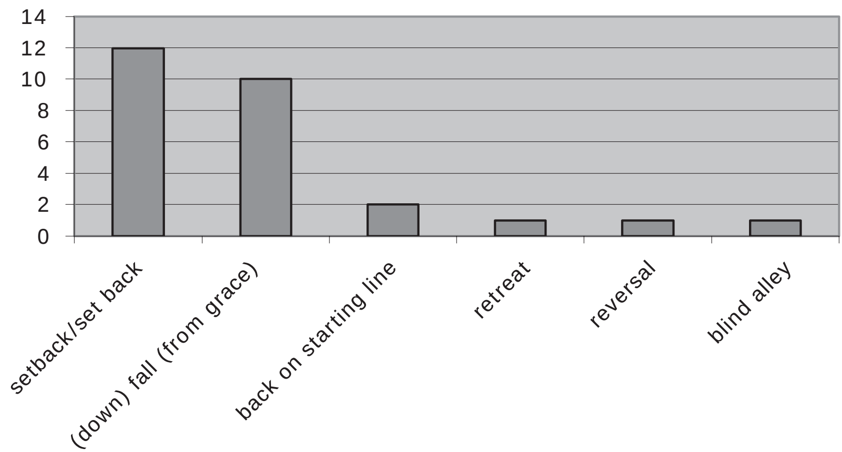

figure 13.2 'Descent' metaphors found in UK national newspapers (15/12/05–12/01/06)

exploit features of a race or journey, such as racing along a path leading upwards, overcoming obstacles or hurdles, passing milestones or landmarks, finding a new path leading to a frontier, moving along a path in a certain way (speed, type of movement etc.), creating the path itself (to pave the way), etc. And, as in a race, when two entities move along the same path, we also find metaphorical references to the way these entities interact: one leading or going ahead, another falling behind, the winner breaking through or leaping over the finish line. Components of the descent frame are less varied: the forward movement is replaced by a backwards one and the endpoint of the path, which had been conceptualized as a frontier, is replaced by a blind alley. Together, these two kinds of movement chart a pathway of success and failure in modern science, a pendulum movement all too familiar to scientists.

e arly expectations hyped up by ascent metaphors were dashed in December 2005 when many journalists had to reverse gear, so to speak, and future patients had to give up their early hopes for miracle treatments.

a more detailed analysis of metaphors used in the press reveals that scientists themselves did not use the word ‘breakthrough’ in any of their quotes. The word is much more likely to appear within journalist commentary and in headlines, such as ‘Asian scientists unveil breakthrough in stem cell cloning from sick patients’ and ‘Scientists hail human stem-cell breakthrough’.

When scientists are quoted they seem to prefer metaphors related to the race frame such as ‘milestone’ or ‘step ahead’:

> Hwang Woo-suk**,** the study leader, called it ‘a giant step forward towards the day when some of mankind’s most devastating diseases and injuries can be effectively treated through the use of therapeutic stem cells’. (*The Financial Times*, 20 May 2005)

> Nonetheless, a spokesman for the Californian biotech firm Genetic Savings & Clone, Inc - which has already produced a cloned-to-order nine-week-old kitten - welcomed the breakthrough. ‘We’ve long suspected that if anyone beat us to this milestone, it would be Dr Hwang’s team - due partly to their scientific prowess and partly to the greater availability of canine surrogates and ova in South Korea,’ Ben Carlson said. (*The Guardian*, 3 August 2005)

It also becomes clear that the use of ‘breakthrough’ does not diminish once breakthrough claims have been revealed as fraud, as the following quotes show:

> And we also learned that Professor Hwang Woo-suk faked his stem-cell research breakthrough in Korea. The news value of medical breakthroughs can go down as well as up. (*The Independent*, 1 January 2006)

> Thus Hwang appeared to have opened up the route to a true scientific breakthrough. (*The Observer*, 1 January 2006)

> The allegations have cast a shadow over all his claimed breakthroughs in cloning and stem-cell technology. (*Daily Mail*, 25 December 2005)

Overall, Hwang’s pathway of rise and fall followed the well-known narrative of the Greek myth of Icarus, a metaphor for the dangers of human hubris. The flight of hubris had to be abandoned and ordinary scientific work and drudgery had to begin again. a s one commentator wrote a year later:

> t he Korean tragedy dealt a painful blow to stem cell researchers the world over. o n top of everything, scientists had been led to believe that the technical hurdles of human therapeutic cloning had been crossed by the Koreans. n ow it was back to the blackboard for those who had hoped to build on Dr. Hwang's accomplishments. (Herold 2007: 198).

t he narrative of h wang's rise and fall undermined traditional views of science as steady and even spectacular progress. Commentators began questioning the validity of scientific peer review and floated proposals for its reform. Journal editors were accused of sacrificing judicious assessment of manuscripts in the quest for the next big story. a nd the pace and competitiveness of biomedical research were portrayed as increasingly out of control, driving scientists toward questionable practices and even fraud (g ottweis and t riendl 2006; for more references, see Introduction, this volume).

t he events surrounding h wang showed that research communities and the media are increasingly under pressure to 'hype up' research findings,[1] something that Lord Winston had already hinted at two months before the scandal broke:

> The potential benefits of embryonic stem cell research have probably been oversold to the public, fertility expert Lord Winston says. He fears a backlash if science fails to deliver on some of the 'hype' around the cells - as he believes may happen. h e says the notion that a host of cures for serious, degenerative disorders are just around the corner is fanciful. (BBC News, 5 September 2005)

t he narrative of hubris perpetuates the view that science is a linear process of steps and breakthroughs, with no account given of the trials and errors that occur along the way (Rick Borchelt, communication). This, in turn, creates unrealistic expectations that science always gets it right. When the inevitable errors occur, confidence in the scientific enterprise is eroded, eventually resulting in a cynical public. By contrast, framing science within narratives of humility would highlight trial and error, explain the significance of failure and encourage the more careful use of breakthrough metaphors. Whether this new way of story telling is realistically achievable in science communication, especially in the news media, is a question addressed by Tim Radford (this volume).

a lthough this sample analysis indicates that the *word* breakthrough seems to be journalistic shorthand for success in science, achieving breakthroughs is always at the back of scientists themselves. This was again made very apparent during the h wang scandal, as expressed in a short piece written by a scientist turned science writer and entitled 'Breakthrough breakdown':

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1 Note that 'hyping up' should not be confused with 'fraud', which is something quite different.

> If a scientist wants stability and adequate funding, i.e. a career, they have to produce. But these days knowledge is not enough; it has to be something that can turn into a 'breakthrough', a patent, or a pill. The pressure to produce, and for experiments to 'work' can be enormous. (Helm 2007/08)

t he politics and ethics of disaster metaphors: t he case of the antibiotic apocalypse

in the previous section, i studied the positive hype/early promises surrounding embryonic stem cells and therapeutic cloning and the use of race and breakthrough metaphors to report on these promises. in this section i will examine the negative hype/early warnings surrounding the rise of antibiotic resistance and the emergence of superbugs. t his means switching from the promises of a new technology to the dangers posed by an old one; albeit one which was once hailed as a miracle. t his also means switching from looking at how governments exert pressure on scientists to achieve breakthroughs to how scientists can exert pressure on government to help them achieve breakthroughs through increased funding.

in 1998 Peter Weingart had observed, with relation to climate change, that exaggeration and, what Weingart calls, 'discursive overbidding' were tools frequently used by scientists in the race to gain public support and public funding.[2] h e speculated that

> [w]hat appears here as a recent and unique development can be demonstrated to be a recurrent pattern. in policy-relevant areas the emergence of new research fields follows the path of climate change research: In the beginning is the claim of an impending danger if not catastrophe. a small group of scientists (from different disciplines) who proclaims this danger also provides suggestions for a solution. t he promise to be able to avert the threat comes with the authority of scientific expertise in a brand new research area and is tied to the condition of needed financial support… (Weingart 1998: 878).

i will attempt to show that the discourse signalling the danger or catastrophe related to the emergence of antibiotic resistance and superbugs seems to follow this template. i will also try to explain the advantages and disadvantages of such 'discursive overbidding'.

in the 1960s 'it seemed as if the war against bacterial infections was over. in fact by 1967 things looked so promising that the US Surgeon General confidently declared: "It's time to close the book on infectious disease"' (James 2005). Instead, the rise in antibiotic resistance led to the emergence of 'superbugs' and the 'war against microbes', which many thought had been won, started all over again.

2 Again, this is quite different from 'fraud'.

e arly warnings about the dangers posed by a rise in antimicrobial resistance and a concomitant rise in superbugs had been sounded from the mid-1990 onwards,[3] mainly in popular science books and medical journals. Some of these warnings were framed by references to the plague, and others with reference to a rmageddon and the apocalypse (Nerlich 2008b). These metaphors are well known in discourses about medical issues and have lost some of their attention-grabbing force. it was therefore interesting to see how a microbiologist and colleague of mine at the u niversity of n ottingham, who intended to grab the government's attention and secure better funding for research, went about framing the dangers of antibiotic resistance by using a novel metaphor.

in the spring of 2005, r ichard James, Professor of m icrobiology at the u niversity of n ottingham, entered the 'apocalyptic' battleground with an article for the u niversity of n ottingham's *Vision* magazine entitled 'Battling bacteria'. In it, he talked for the first time of a 'post-antibiotic apocalypse' (James 2005); a novel metaphor intended to change the discourse and practices surrounding the use of antibiotics and the treatment of superbugs. o n 7 January 2006, *The Guardian* published a lengthy interview with James entitled 'War on t error', in which James outlined 'his vision of an apocalypse'. t his was followed a month later, on 1 February, by an article in the *Nottingham Evening Post* entitled 'o ur future at mercy of deadly superbugs'. a s in 2005, competition and war-metaphors abounded. James was 'on the warpath'. His aim, it seems, was to influence policy makers by changing their perception of how to deal with antibiotic resistance and superbugs and promoting new research in the area. t o achieve this aim he chose a powerful and quite novel metaphor which framed the issue of antibiotic resistance in a very negative, 'end of the world' way, but he also employed a number of older and well-worn medical metaphors linked to the war scenario.

o n 5 January 2007, the u niversity of n ottingham opened a new Centre for h ealthcare a ssociated infections at the u niversity of n ottingham and issued a press release that quoted James as saying: 'Quite frankly, the impending crisis on the horizon can be called the "post-antibiotic apocalypse".' Whereas James's uses of the same metaphor in media interviews in 2005 and 2006 were isolated events, the repetition of the phrase, as framed by the launch and press conference, reverberated through the regional, national and international press.

in order to trace the emergence and spread of an apocalyptic discourse in infection control I first searched Lexis Nexis Professional (UK) using the search words *antibiotic* and *apocalypse*. 25 articles were retrieved, published between 1996 and 2007 (some articles had to be discarded as they dealt with topics unrelated to the focus of this article). James was the first, in 2005, to use the compound phrase 'antibiotic apocalypse'. a further corpus of articles was retrieved using a l exis n exis Professional version that gives access to articles published in e nglish-speaking news-outlets world wide. This time the keywords were *Richard James*

3 a lthough debates about these dangers had begun as soon as antibiotics themselves appeared in healthcare.

and *Nottingham*, in order to capture the media output after James used the phrase 'post-antibiotic apocalypse' in a deliberate discursive move to attract attention.

When talking about this apocalyptic scenario, framed by his well-chosen metaphor, James also used other metaphors, common in microbiologial and infectious disease discourse, in which dealing with disease is a 'war' or 'battle'. As it turns out, he used these metaphors quite unconsciously and tacitly (see James 2007a). However, the combination of the consciously chosen disaster metaphor and the unconsciously chosen war metaphors was a potent mix. Let us now take a closer look at the 'language of war and apocalypse', first in its rhetorical form, then its function, then its implications.

We begin with some examples of war metaphors found in the two corpora. People, at various times, 'fight against healthcare associated infections', 'combat superbugs', 'battle against MRSA "apocalypse"', 'spearhead the fight against killer superbugs' and, ultimately, 'defeat MRSA and other superbugs'. There are also race metaphors, such as the 'race between human beings and their microbial foes', the 'arms race' and the 'struggle to keep up'. Most importantly, bacteria are conceptualised as autonomous agents in a war or race. For example, 'microbes really fight back', 'the battle is swinging back in favour of the bacteria', 'disease-causing organisms have a range of weapons' and 'we're not fighting guerrillas taking pot shots here'. Microbiologists tended to promote scientific methods as 'weapons' in a war and characterised themselves as 'work[ing] on biological warfare' or 'experts in biological warfare'. Journalists also used such metaphors and, in some cases, editors chose headlines, such as 'War on terror', that reflected and amplified this type of language. Overall, however, and in contrast with the use of breakthrough metaphors, war metaphors are scientific currency in microbiology, to the extent that some microbiologists, such as Joshua Lederberg (2003), have called for an end to war metaphors and 'making peace with microbes'.

in general, scientists have portrayed bacteria as rather clever agents whose ingenuity they can admire, albeit grudgingly. in contrast with the h wang case, where race metaphors framed the search for success by two teams of scientists, race metaphors here frame the interaction between scientists and bacteria.

'War' and 'competition' metaphors have been a long-standing currency in medical discourse (see Hodgkin 1985; Warren 1991; Annas 1996; Larson et al. 2005, Chiang 2007 and many more). From the time of Louis Pasteur onwards, dealing with bacteria or germs has been framed in terms of waging war or what Montgomery (1996) calls 'biomilitarism'. From the 1940s onwards, when antibiotics became widely available, their use was also framed in terms of a war against invading bacteria. t hey were characterised as a 'silver' or 'magic' bullet in the fight against infectious diseases. And, in a sense, they were literally weapons in a war; the first really significant antibiotic, penicillin, was seen as vital to the allies winning the Second World War. For a time, antibiotics were hugely successful, to the extent that the dominant war frame accompanying their use might have obscured the exploration of and investment in other technologies, such as immune response therapies.

When highlighting the rapidly diminishing powers of antibiotics in this war against bacteria, the metaphor of the antibiotic apocalypse can be useful, but it may also have disadvantages. Although it raises the profile of the problem and places it on the public agenda, it might be counterproductive in the long term. t he apocalypse is usually seen as the inevitable 'end of the world' against which humans are powerless. But this is not what James and his colleagues want to achieve when using this frame. instead, they seem to follow a more secular tradition of viewing the apocalypse as a disaster which can be averted through human agency. t his view has been popularised by a number of films, from *Apocalypse Now* (released in 1979) onward, in which apocalyptic discourse focuses:

> on human ingenuity in avoiding the end rather than on the inevitability of cosmic cataclysm. in these contemporary, cinematic apocalyptic scenarios, human action (often based on stupidity or greed) directly or indirectly leads to an apocalyptic disaster; therefore, human beings supplant cosmic forces as the initiators of the apocalypse and must take the role of saving the planet from apocalyptic destruction. (Ostwald 1998)

in the case of superbugs, ingenuity is indeed needed to develop new diagnostic technologies for improving the detection of pathogens. But political acceptance of the scale of the problem and the implementation of a strategy to significantly reduce it are also essential. By advocating a new, albeit dark, vision of future health care, James wants to spur politicians into action and create expectations; specifically, the expectation that scientists will do something to alleviate the problem of antibiotic resistance, if only politicians are willing to fund their research. t his discourse is also intended to reverse older expectations surrounding the miracle properties of antibiotics which led to the overuse of these drugs. Creating new expectations and reversing old ones is designed to lead to changes in behaviour, practice and funding.

h owever, there may be a danger that the language used – the one salient and consciously chosen metaphor of the apocalypse together with the surrounding, rather more unconsciously chosen, war metaphors – actually impedes these desired behavioural changes. a s h ulme has pointed out with relation to climate change and 'catastrophe discourse':

> Campaigners, media and some scientists seem to be appealing to fear in order to generate a sense of urgency. if they want to engage the public […] this is unreliable at best and counter-productive at worst. […] such appeals often lead to denial, paralysis, apathy or even perverse reactive behaviour. (Hulme 2007)

t he results achieved by early warnings framed in terms of fear might be similar to those achieved by early promises framed in terms of hope. If unfulfilled, they can both lead to public cynicism, loss of trust and disengagement.

in conclusion, using the metaphor of the ‘post-antibiotic apocalypse’ when talking about health care associated infections has advantages and disadvantages. its alarmist tone alerts politicians to a situation that needs urgent attention, alerts funding bodies to new lines of scientific research and might reverse ordinary people’s expectations regarding ‘miracle drugs’. Similar to the ‘breakthrough’ discourse discussed in the first part of this chapter, an apocalyptic discourse may provide the winning edge in the competition for research funding and political attention. However, it could also induce fears which stifle behavioural change on the level of human populations, just as talk about breakthroughs might raise hopes which, when dashed, can change attitudes towards certain technologies or scientific advances. Overall, my analysis seems to confirm findings by Saguy and Almeling (2004: 53) that

> scientists work as “para-journalists” (Schudson 2003), writing up their studies – especially the abstract – with journalists in mind. They then frame their research via press releases and interviews with journalists. A reward structure in which, all things being equal, alarmist studies are more likely to be covered in the media may make scientists even more prone to presenting their findings in the most dramatic light possible.

Conclusion

Announcing impending breakthroughs and warning of impending disasters are legitimate speech acts carried out by scientists and science communicators in order to get their message across to funding organizations, politicians and the public. h owever, the new culture of science funding may pervert such legitimate speech acts and metaphors in science communication. t o get funding in a highly competitive environment, scientists are increasingly using breakthrough and disaster discourses to enhance the visibility of their research to funders and, through the media, the public at large.

in a recent article, l awrence points to several emerging trends in science communication, although i shall only highlight two in the context of this chapter. The first is that ‘scientists learn to hype their work, making a story more simple and sensational by ignoring or hiding awkward results’ and the second is that ‘the struggle to survive in modern science has’ (Lawrence 2007) made use of the publicity. In this context, the use of breakthrough and disaster metaphors is a very difficult rhetorical and ethical balancing act. Overhyping breakthroughs and disasters may lead to public cynicism and metaphor fatigue, especially if positive or negative expectations are left unfulfilled when the promised breakthroughs and disasters fail to occur (Nerlich and Halliday 2007).

The influence of metaphors on the public perception of issues relating to science and health has been studied for many years, especially with regard to cloning research, gm food, so-called 'designer babies', stem cells and, perhaps most intensively, the human genome project. In a recent report, Paul Martin and Michael Morrison (2006) have urged readers to rethink what has so often been called the 'genomic revolution'. They stress that stakeholders need to be realistic about the scale of innovation in genomic medicine and the speed at which it will arrive. t hey should realise that biomedical innovation is a slow and incremental process, not a 'revolution.' Martin and Morrison assert that acknowledging this fact may help members of the general public understand the innovations most likely to affect them in the medium term and thus adopt them more effectively.

Creating critical awareness of the metaphorical enactment of certain 'scripts' or 'frames' in the process of science communication, whether it is intended to create positive expectations or negative ones, to create hope or fear or to make promises or issue warnings, should therefore be an important task for sociologists, linguists and other scholars. o nly then can 'the public' engage critically with science in society.

a cknowledgement

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Chapter 14

Craig Venter and the r e-programming of l ife: h ow m etaphors Shape and Perform e thical Discourses in the m edia Presentation of Synthetic Biology

a ndrew Balmer and Camille h erreman

Introduction

Synthetic Biology[1] is a rapidly growing interdisciplinary science at the confluence of biology and engineering. it focuses on the design and fabrication of biological systems through the ‘writing’ of DNA. This newest field in the ‘new’ genetics is increasingly seen as a paradigmatic shift in our relationship with nature. in this chapter we will show that when scientists and the media try to convey its novel features and promises, they tend to use a language which, although rooted in the discourses used to frame older genetic advances such as genetic engineering and the decoding of the Human Genome Project (HGP), changes the focus of metaphorical framing from interpreting and altering to inventing and fabricating. This underlines both the field’s continuity and similarity with what has gone before but also signals various discontinuities and differences.

We aim not only to investigate the rhetorical function of metaphors used by scientists and journalists when writing about synthetic biology, but to understand their inherent ethics and the implications this may have for public understanding of this field. With claims as bold as the creation of artificial life,[2] it is unsurprising that the emergence of the field and its early successes have caused a stir in the media. t his stir was in part engineered through a concerted promotion campaign orchestrated by a major player in the field and one of the most ‘visible’ scientists

1 The dominant neologism for a field variously named ‘intentional biology’, ‘biological engineering’ and ‘constructive biology’ among others. We use ‘synthetic biology’ throughout.

2 A phrase used prolifically in the media with regard to the activities of Craig Venter. For example see: ‘Scientists ‘closer to creating life’’ (*Daily Mail*, 29 June 2007), ‘Creation of artificial life brought a step closer by DNA transplant’ (*The Times*, 29 June 2007), and ‘Playing God; The man who would create artificial life’ (*The Independent*, 25 January 2008).

(Goodell 1977) of the last decade: Craig Venter, an American scientist heading the J. Craig Venter Institute, which was set up specifically 'to save the world' (see Shreeve 2004: 373). Former co-decoder of the human genome, one reporter notes, he 'has become the poster boy of synthetic biology' (Conner 2008).[3] t his chapter investigates the traces left by one of Venter's promotional campaigns in the media, specifically that carried out in the UK. It examines the metaphorical framing used by Venter, his collaborators and the journalists they spoke to and treats this as a form of ethical discourse.

Some of the ethical issues are summarised in a report prepared by Balmer and Martin (2008). They include the need for scientists to engage with the public early in the development of synthetic biology to ensure that research does not get ahead of public attitudes; synthetic biology must not be over-hyped by its supporters and critics should not exaggerate the risks it poses; current regulations and guidelines should be reviewed to ensure that an appropriate governance framework is in place before synthetic biology applications are introduced. in many respects, Venter has done what this report asks of scientists. He has engaged widely with the public through lecture tours, debates and media appearances and he has openly expressed some of the ethical challenges faced by the field. This kind of direct engagement with the public and his expertise in working with journalists indicates that his framing of the issues may significantly influence the discourse generated in coverage of the field, which makes it even more interesting to delve into the language he used in his public engagements and its ethical implications.

Methods and corpus

in this study we focus on newspaper articles to explore discourses surrounding synthetic biology. We are interested in the tone and content of the messages rather than how this information is received and understood. We combine metaphor analysis with frame analysis, a combination of tools that has been used successfully in recent years in media studies and in science and technology studies (STS) to reveal hidden agendas, ideologies and beliefs about emerging technologies (e.g. Coveney et al. 2008). It is important to analyse media data to understand the way metaphors are used to draw parallels between seemingly unrelated concepts and to make the novel or unfamiliar appear familiar.

We used the newspaper database l exisn exis Professional to locate articles written since 2000 that mentioned the search term 'Craig Venter'. We collected a body of over 400 news articles. After reviewing these and rejecting irrelevant pieces or pieces that only referred to synthetic biology in passing, we eventually adopted a corpus of 50 u K articles that were written during, and with regards

3 Professor at Stanford u niversity. h is approach has drawn upon Web 2.0 and is thus much more interactive than Venter's. Future work could investigate if these divergent communication practices produce different understandings of the field.

to, Venter's work and had a substantial focus on synthetic biology. The selection process was debated between the co-authors who substantially agreed on which articles to include or exclude from the final corpus. Our inter-coder reliability was about 90 per cent.

Through an in-depth qualitative analysis of these news articles, certain themes began to emerge quite clearly, themes that clustered around a number of prominent conceptual metaphors. Some of these are long-standing new science metaphors that are already familiar from Human Genome discourse (see Kay 2000). Other metaphors begin to emerge, it seems, quite specifically in order to provide suitable analogies for the representation of the inner workings of synthetic biology, as well as for the promotion or critique of this new science.

According to the cognitive view of metaphor (Lakoff and Johnson 1980), metaphors help us understand an abstract or inherently unstructured subject matter in terms of a more concrete, more highly structured subject matter. Metaphors are not only linguistic but cognitive phenomena, they are necessary for our thinking, acting and speaking (Ortony 1979). They are conceptual devices, rather than rhetorical ones, and, we would add, they are also social devices. in cognitive linguistics, conceptual metaphors, such as argument S are War (and their linguistic realisations, e.g. 'He spearheaded the debate') are seen as mappings across at least two conceptual domains: the conceptual source domain (e.g. war) and the conceptual target domain (e.g. arguments). We develop this position by treating the production of such mappings as an act of ethical discourse. in the example above, we would argue, that when one moves from a source (war) to the target (arguments) the ethical relationships are also transferred. To treat arguments as wars allows for and legitimises certain behaviours that might not otherwise be ethically acceptable, for example the attempt to 'destroy' an opponent. By following this position we are able to treat metaphors *as* ethical statements.

t hese mappings between source and target domains are not arbitrary. r ather, they are grounded in our everyday experience of the body and the world we live in. a s we shall see in the following, many of the conceptual metaphors used to structure the promotion of and debate surrounding synthetic biology are derived from our knowledge of old and new types of technology, from books to computers and beyond. The kinds of metaphors *as* ethics that are used in the media discourse of synthetic biology will certainly be influenced by their context but, we contend, they may in turn influence that context and re-configure previous understandings of our selves and our environments.

Backdrop to the media staging of Venter and synthetic biology

Venter has a reputation for patenting his research and discovering new ways of generating personal capital through scientific research. Certainly Venter is pushing synthetic biology forward on the back of various altruistic aims, which we explore below, but this has not reduced the corporate dimension of his work. Venter is not hiding his capital-oriented approach either; in an interview with *Newsweek* he asserted that the processes his teams were developing would be patented and that if they made an organism that could produce fuel they would patent that process also, since it could be 'the first billion- or trillion-dollar organism' (Sheridan 2007). Venter's private company and his not-for-profit institute are garnering funds from both public and private sources, as is the field of synthetic biology more generally, most evidently in the United States of America (Balmer and Martin 2008).

Although it is often viewed as a new and emerging field, synthetic biology and its relations with the media inevitably rest on past interactions: genetic engineering and the HGP. These precede Venter's current work and provide clear examples of how societal repulsion or endorsement of a branch of genetics can affect scientific endeavours (see CSEC 2001). Media coverage of Venter has been extensive. As a controversial, outspoken and 'anti-establishment' figure with an interesting history, he makes for easy and pleasing articles in a range of news publications. h is previous actions have resulted in a characterisation as the 'bad boy' of science – an epithet he doesn't mind, as long as he isn't called the 'evil' boy of science (Shreeve 2004: 238). He became the antidote to the softly-paced and communal effort of the hg P: a shot-gun wielding geneticist-cowboy.

Despite the potential ethical controversies surrounding synthetic biology, Venter's synthesis work is yet to encounter the same level of negative media coverage as did genetically-modified (GM) crops, or his financial ambitions with the hg P. h ow is Venter publicly and metaphorically managing the inherent antagonism of fear and hope? What stylistic changes have occurred in the presentation of his research to the media; in other words, how has Venter recreated himself and what can we learn about the potential for public-media ethical dialogue over the application of synthetic biology?

f rom the 'book of life' to 'building machines': Problems for regulation

Following from the central use of the 'book of life' metaphor in discourses that relate to genomics, it is interesting to note that within the corpus there was very little reference to that dominating metaphorical frame, although it should be said that Venter rejected that metaphor after the completion of the genome project (see Nerlich and Hellsten 2004). Reference to a book was only found, with relation to synthetic biology directly, in the context of a recipe book in a *Times* comment piece. t his was perhaps used with reference to the *Anarchist Cookbook* (Powell, 2003) since it is deployed alongside fears of bioterrorism: 'Could synthetic biology be used to build bioweapons? Yes. Once it's proven that we can cook up fully functioning bacteria and viruses, the recipe book can be used for good or ill' (Ahuja 2007).

Although the metaphor still refers to a bank of knowledge that can be used by humans for our own devices, as with the HGP, the book itself has been domesticated. It is no longer the great and foreboding 'book of life' that resonates with the biblical book of revelation but rather a recipe book for budding scientists or dangerous individuals to get their hands on. Certainly the idea of a recipe book connects more easily with the emerging fears over garage biology (see below). The metaphor of the recipe book is not new in genomics but assumes a different and more disturbing meaning in this context.

The reading (the book of life) metaphor is being displaced by its natural successor, writing, which is used to explain that synthetic biology has shifted towards control and creativity when compared to the interpretative and pedagogical notions heavily deployed in the hg P. t hough there is metaphorical continuity from reading (a product of creativity) to writing (engaging in creativity and producing something), it is not a literary writing frame that we find ourselves within any longer, rather it is computational writing: instead of 'discovering' the 'book of life', the work of synthetic biology is more akin to the development of software, as one of Venter's co-workers states:

> I like the analogy with a computer. You have an operating system which, by itself, doesn't do anything, but when you install it on a computer, then you have a working computer system. It's the same with the genome. The genome is an operating system for a cell and the cytoplasm of the cell is the hardware that's required to run that genome. (Conner 2008)

Furthermore Venter describes the genome transplant his research team accomplished as being 'like changing a Macintosh computer into a PC by inserting a new piece of software' (Highfield 2007b). The metaphor that Venter and his colleagues are using is repeated in the coverage of their work, as a news report describes:

> t he synthetic biology that Venter is pioneering springs from an attitude that scientists are building machines, not living things. t hese are seen as computers capable of replicating themselves, with genes as software controlling hardware cells – a view that dates from Watson's and Crick's discoveries in 1953. But Venter is taking the process to a new level by creating new hardware and software where none existed. (Anon 2007b)

t he computing metaphor has completely permeated the press; the *Daily Mail* writes: 't hey managed to swop the entire genome – the genetic software containing information for life – of a bacterial cell with one from a different, but related, bug.' (Ballinger and MacRae 2007) Talk of 'programming' microbes is also used: 'n ow the inventor [Venter] plans to design new codes on computers to programme synthetic microbes to produce fuel from sunlight' (Anon 2007b), and elsewhere: 't his will create a life form with biological instructions written entirely by humans' (Henderson 2008). Again, the code metaphor is old, as old in fact as modern genetics (Kay 2000), but what was once a metaphor used to construct genetic theories about the workings of DNA or to explain these workings to pupils in textbooks or to the public in newspapers, has turned literal and practical in this context. Griffiths (2001) argues the ‘information talk’ surrounding the link from genes to amino-acids is not a true account of how genetics relates to behaviour but rather a reflection of the present dominance of information technology in contemporary culture. This metaphorical writing of software extends what Griffiths finds in genetics: a will to see genes as intentional information.

What implications should we draw from this metaphorical shift? t reating these metaphors *as* ethics we find that a highly instrumentalist approach to the ethics of synthetic life is being embedded in the media discourse. t his computational metaphor, made up of phrases like ‘the genome is an operating system’, ‘a life form with biological instructions written entirely by humans’ and ‘the genetic software containing information for life’ is a conceptual mapping from programming to genetics. Such a conflation of types of code and the direction in which the metaphor is formulated, from software to cells, implies that as with the programming language of a computer, the genetic language is the entirety of the organism’s system. t his signifies total mastery over the operations, i.e. the behaviour, of an organism and produces a concept of life that is entirely mechanistic. t he ethical implications of such a metaphorical mapping relate to how we position the organism on the boundaries of living/inanimate and synthetic/natural. interestingly this metaphor draws on the synthetic, programmatic aspect of the organism whilst maintaining its living, natural status. t his ostensibly contradictory construction allows Venter’s microorganisms to fit comfortably into various other motifs deployed within the discourse, each of which has a particular rhetorical power. t he immediate effect of this instrumental, computational metaphorical positioning of the organisms as programmed is that ethical attention is no longer concentrated on the form but the process.

t hese analogies move us away from interpretation of the existing genetic code and towards creation of new codes, away from literature and towards computation; they perform a reframing of the ethical discourse from one of biological monstrosity, as in the case of Frankenstein foods, towards a more sedentary role for the organism. t he upshot of this is that the inventor becomes the source of ethical trouble. it seems that in synthetic biology our fears centre on the possibility of human error or maleficence. Within the computational frame the designed/synthetic aspect of the organism is highlighted, which reduces the life-like quality of its behaviours and, in coordination with this instrumentalist discourse, the stage is reoriented. t he spotlight moves from the monstrous creation to Dr Victor Frankenstein himself, the scientist who is doing the creating. Whether or not Venter intends to situate the scientist at centre-stage matters little for the performance. But perhaps *our* metaphor goes too far: the media is not a stage and the metaphorical frame is not a spotlight; the audience of a newspaper may choose what they read, they may still make the connections to Frankenstein’s monster even if the journalist does not. t here is a gap between our analysis of how metaphors are deployed in media discourse and their effects on public opinion.

During the gm debate, crops and food were the focus of public anxiety and fears. t he plant geneticists that might be involved in producing them were almost invisible. When the deciphering of the human genome was announced, to some degree the focus shifted onto the scientists, some of whom, like Venter, became very visible indeed, almost celebrities. So, whilst there is some incongruity between framings of GM and SB, we find a degree of continuity between the ethical shaping of the HGP (see discussion on corporatism below) and the shaping of synthetic biology. h owever, none of these previous scientists had claimed to ‘create life’.

Whereas in the real or fictional past, the creation of life may have been in the hands of exceptional individuals (Dr. Frankenstein), this may no longer be the case in synthetic biology. Although this field has its visible scientists, such as Venter and e ndy, it is also open to anybody who wants to give it a try. t his opens up yet other ethical issues, this time not related to personalities but to the wider scientific public, not only in terms of fearing or admiring its end-products but in terms of producing them.

t his human-centric approach to ethical issues is evident within emerging talk of ‘garage biology’, a term that refers to the use of microbiology and DNA synthesis tools at home – a form of ‘bricolage’ that the biologist François Jacob could only have dreamed of (Jacob 1977). The decreasing costs of those tools may be starting a biological equivalent of the programming era, as Rob Carlson (2005), a prominent synthetic biologist writes: ‘The advent of garage biology is at hand. Skills and technology are proliferating, and the synthesis and manipulation of genomes are no longer confined to ivory towers.’ Or as Markus Schmidt (2008) writes: ‘it is likely that in the future more and more people without a traditional education in biology or genetics (and probably even without higher education) will be able to manufacture biological systems.’

t he programming metaphor underlies this fear of garage biology. Schmidt fears that ‘t he more successful the attempts to program Dna as a 2-bit language for engineering biology … the more likely will be the appearance of “bio-spam, biospyware, bio-adware” and other bio-nuisances.’ Of course it isn’t just the trifles of what we might call l ife 2.0 that one would have to contend with, but the worry that ‘[a]n unrestricted biohackery scenario could put the health of a biohacker, the community around him or her and the environment under unprecedented risk’ (Schmidt 2008). And in the media coverage, journalists ask: ‘what happens if a DNA hacker with evil intentions finds a way to isolate the nastier bits of the smallpox or a ids viruses, then splices them into another, to unleash on the world?’ (r owan 2006). There is a metaphorical continuity here from the computational metaphor that sees scientists as writing software for cells, through the garage biologist who hacks DNA, through to the dispersal of the results into the environment as ‘viruses’, which brings the metaphor full circle back to its origins in biology.

It isn’t solely garage biologists (or ‘biopunks’) that are seen as potential threats but scientists also, those who might allow a synthetic organism to escape from the lab and those who might release it intentionally. Researchers at Stonybrook University synthesised the polio virus (Cello et al. 2002) and others developed the pandemic Spanish Flu virus of 1918 (Tumpey et al. 2005). Both of these experiments caused a stir in the media, prompting discussion about the ethics of scientific practice and feeding into the then hyperactive fear about terrorism.

t his scientist-centric ethics is also evident in the discourse developed by various colleagues of Venter's in a recent report (Garfinkel et al. 2007) on ethical issues in synthetic biology. It emphasises the need for scientific practice and regulation. Perhaps this serves to move the debate somewhat from a form of deontological ethics, meddling in the natural world, to a far more utilitarian one, in which we must take into consideration the risks posed by scientists rather than science. h owever, this connection to computation still lends itself to claims of scientists 'tinkering' with life, and altering the natural world. Described as ominous by a *Times* journalist, an MIT scientist is quoted as saying, 'The genetic code is 3.6 billion years old. It's time for a rewrite' (Anon 2007b). This rewriting, this creation of 'new hardware and software where none existed' (ibid.) is what underlines much of the ethical dimension of synthetic biology. As the field is increasingly seen through this metaphor, the ethical issues to be debated are likely to move towards regulation of scientific practice and proper laboratory and purchasing procedures and away from discourses of the un/natural or even artificial, a word still used in discourses around synthetic biology.

In the following we will first outline some of the more negative coverage that the computational metaphor provoked, stoked in part by a critique from an NGO working prominently in this field. We shall then outline some of the more positive images also discussed in the British press coverage, which link synthetic biology not to capitalist landgrabs (see below), but to saving the planet from the ravages of climate change – a discourse of hope that, like so many discourses of hope in biotechnology, remains unfulfilled, but which counterbalances any fears that memories of genetically engineered plants or animals may still provoke in the public sphere.

Industrial rhetoric, the patenting problem and Venter the evil genius

h aving suggested that the metaphorical framing of synthetic biology through the computational frame performs a re-focusing of ethical trouble from the organism to the scientist, which had begun in the h g P, we argue that the second effect of this programming language is that it may support claims to novelty regarding the patentability of such things as the minimal genome.[4] By emphasising the 'design' of organisms and seeing the scientists as engineering the software ,we are encouraged to conceptualise their outputs as products. t his programming metaphor, therefore, may also be embedded within a parallel ethico-legal discourse on the intellectual property

4 m inimal genomes are the output of Venter's institute. t hey are bacteria that have had all the non-essential genes removed from their genomes, so that they can have particular genetic sequences put into them. This is the process through which Venter intends to produce bacteria that can synthesise biofuels or clean up the environment.

status of the output of synthetic biology. Rai and Boyle (2007) suggest that synthetic biology might bring together the ways that the u S separately handles patenting and copyright and that this could represent the 'perfect storm' for intellectual property law. m uch of such bad weather reporting was prompted by Venter's attempts to patent the minimal genome, which he attempted in the u S and at the international level through the World intellectual Property o rganisation, number Wo 2007047148. More recently Venter filed patent applications for making synthetic genomes (UPSTO no. 20070264688) and putting them into cells (20070269862). This computational metaphorical work may serve to highlight the non-natural, formed, 'created' dimension of synthetic organisms, not simply as an explanatory frame, but as a tool in *constructing* synbio products as designed and novel, thereby facilitating their patentability. By conceptualising the organism as hardware and the synthetic genome as software the ethical contestations surrounding the patenting of life, which has previously been highly controversial, are potentially undermined.

Further to the theme of computer engineering, the language used by newspapers frequently deploys what can be interpreted as a rather industrial metaphor. Due to the inter-disciplinary nature of synthetic biology, vis-à-vis its ties to engineering, this metaphor sits easily with both computer analogies and those of capitalist industry. We read in *The Times* that 'microbes can become bespoke factories' (Ahuja 2007), likening the process intended for manipulation of microbes to a sophisticated production line. t hat Venter has 'constructed a synthetic chromosome' (r anderson 2007a) alongside mention of an 'assembly process' (ibid.) suggests nuances of modern industry. By describing the organism as 'off-the-shelf,' in terms of the microbe itself or its genes, the media strengthens the image of industry, of pre-made products fabricated en masse and readily available. t he products of synthetic biology, we are encouraged to think, will be as commonplace to everyday life as a pre-packaged shirt and tie combination.

Within the corpus of u K newspapers, it is really only the Canadian pressure group et C – or the a ction g roup on e rosion, t echnology and Concentration – that reaches newspaper articles as outspoken critics of Venter's work. They have, for example, used the term 'm icrobesoft' to describe Venter's move: 'a suite of patent applications lodged by J. Craig Venter and his colleagues claims exclusive monopoly on a wide swath of synthetic biology and demonstrates a not-so-subtle move to position Venter's company, Synthetic g enomics, inc., as the 'microbesoft' of synthetic life.' (ETC 2007b)

By using the phrase 'microbesoft' the pressure group encourages the industrial/computational metaphorical frame. t his is rhetorically successful since the frame already highlights the patenting claims that Venter has made. h owever, by implicating global capitalism, they challenge the ethical erasure. h ighlighting the profit motive may serve to undermine the public acceptance of the patentability of these hardware organisms and their software genomes. t he et C connect this programming language to patents, industry and monopolisation of a market to re-characterise Venter as a corporate villain; a narrative is developed around the character, both personal and professional, of Venter.

Journalists in the u K media report that Venter is ‘dubbed Darth Venter for wanting to charge the human race a fortune to read its own genetic code’ (a non 2007b). This is used to describe him in the context of the HGP. The description continues: ‘n ow the balding Vietnam veteran has another *cunning plan*: to get exclusive rights to the *bare essentials of life* and create green fuels that will make him a dollar trillionaire’ (Anon 2007b, our emphasis). More dramatically, Venter has also been named, ‘the bogeyman of modern science…pilloried as the unacceptable face of science for profit, the man who wanted to turn the essentials of human existence into patents to enrich himself’ (Pilkington, 2007).

Taken directly from the ETC press release, *The Daily Telegraph* (Highfield 2007a) quotes ETC affiliate Pat Mooney as saying, ‘for the first time, God has competition. Venter and his colleagues have breached a societal boundary, and the public hasn’t even had a chance to debate the far-reaching social, ethical and environmental implications of synthetic life.’ This anchors a critique of Venter’s enterprise clearly in past discourses of scientists playing g od, especially in the context of genetic engineering. t his is intended, one can assume, to stir discomfort in readers, due to its heretical angle. The quote ‘God has competition’ (originally from: ETC, 2007c) was used on several occasions within the corpus and again, by use of a kind of essentialist argument this highlights the scientist as the source of ethical concern.

By playing in the same field, by mobilising their discourse around the computational and patenting metaphors, and linking this, via ‘microbesoft’, to a negative conceptualisation of capitalism, the et C is able to advance an argument against Venter, the representative of synthetic biology more generally. t hese rhetorical moves allow them to play into a super villain narrative that, superficially, appears as comic book rhetoric: Venter, the scheming ‘mad scientist’ is ‘playing g od’ and collecting the riches of the seas and lands to use these ‘essentials of life’ to ‘enrich himself’ and line his pockets. Certainly this makes for exciting reading since Venter’s evil plans provide a perfect hook on which to hang the ethical dilemmas. h owever, the discourse as a whole functions not only as a form of entertainment but as a frame through which one might view the emerging field and its associated hopes and fears.

h owever, much of Venter’s rhetoric promotes a much more positive image of him and synthetic biology that helps to tame the monsters of capitalism and genetic modification. He is here not to exploit the planet but to save it from the dangers of climate change. Through his own comic book narrative Venter characterises himself as a super hero, a Captain Planet of the 21st century.

The greening of genetic modification and Venter the saviour of humanity

Climate change is a concern that has dominated the media’s attention over the past few years, so much so that perhaps such level of attention represents an obsession. The Institute for Public Policy Research released findings by Ereaut and Segrit

(2006) suggesting that alarmist language used in the media to discuss the issue was tantamount to 'climate porn', offering a thrilling spectacle of impending disaster but ultimately distancing the public from the problem. t his research revealed the use of various linguistic repertoires, or systems of language, that are routinely used for describing and evaluating actions, events and people in the context of climate change. o ne of these repertoires, pragmatic 'techno optimism' is arguably apparent within Venter's discourse and its reporting in the press. t his techno optimism relies on technological solutions to planetary problems and utopian visions of the future, from geoengineering to synthetic biology.

The Sunday Times, when discussing different technical means of combating climate change, describes Venter's work as more natural than many: 'Other researchers [i.e. Venter] are seeking more natural solutions. Most of these focus on exploiting the tiny marine algae that fill the upper layers of the world's oceans' (Leake 2007). This seems more organic, than say solar panels and wind turbines. t he way that Venter's venture seems to offer solutions to the environment alters the frame of discussion to a more altruistic one, distant from suggestions of corporatism. Use of the metaphor of 'lungs' compares the microbes Venter is working on with breathing apparatus for the earth and encourages a natural, harmless framing of microbe synthesis. it suggests a healthy symbiotic relationship between microbe and planet, and thus between Venter and planet:

> a merican scientists are studying ways to give the e arth a new set of 'lungs'', vast colonies of bacteria and other microbes that are able to scrub the atmosphere of greenhouse gases such as carbon dioxide and methane and perhaps even convert the pollutants to ethanol, which can be used as a fuel. (Highfield, 2007e)

Personifying microbes as agents 'scrub[bing]' the earth highlights a cleansing process which adds positive connotation to ideas of synthetic biology: we might be able to clean up our act if we can just get the technology right. Purification of the earth might also purify our thinking of the 'stains' left by Frankensteinian monsters on public perception of genetics.

t he connection between synthetic biology and green-ness is often deployed in a single breath, as with *The Daily Telegraph*'s discussion of Venter's work: 'Synthetic g enomics, a u S company run by Dr Venter, recently submitted worldwide patents on methods it has developed to create synthetic microbes to create greener kinds of biofuel' (Highfield 2007d). The familiar metaphor, 'environmentally friendly' is used prolifically in the discourse with regard to the fuel that may potentially be produced by Venter's microbes: 't he team, led by Craig Venter…wants to build new microbes to produce environmentally friendly fuels' (Sample 2007a). This ties in with further language implying assistance and help provided directly by the microbes: '…bacteria which could help mop up excessive carbon dioxide and help combat global warming or provide biofuel or remove carbon' (Randerson 2007a).

t his is again apparent, for example, in *The Independent* when it states, 'Dr Venter said that the aim of the research is to make new, artificial life forms that can help to solve the world's most pressing environmental problems, for instance by producing green biofuels, breaking down toxic waste or even absorbing carbon dioxide from the atmosphere' (Conner 2008). This language suggests helpful bacteria that provide solutions to the planet's problems and characterises the science as value-led. The bacteria may be artificial, but they are also green.

in this context Venter becomes an eco-hero, rather than, as the e t C suggested an 'extreme genetic engineer'. t his positive image is connected to the naturalisation of the organisms Venter is working on and is fostered through attribution of a life-or-death scenario to the research, as repeated in several articles: 'it is important to understand the role and function of these organisms to ensure the survival of the planet and human life on it' (Highfield 2007e). If Venter can't do his research, if we don't work with the environment and give it a new set of lungs we might all be doomed. t his emphasis on the heroic importance of his mission leads to him being likened with adventurers and pioneers, most notably, Darwin: 'The modern answer to Charles Darwin's 19th century voyage upon HMS beagle' (Highfield 2007c).

t his comparison, it can be argued, directly contradicts ideas of science-for-profit and corporatism. One finds in this metaphorical framing an adventurer who might lead us, in collaboration with the friendly environmental organisms, into a greener, more natural relationship with our planet.

t here are two opposing discourses, then, that both utilise the same rhetorical strategy: to set-up a battle between the fate of humanity and an enemy: in one instance Venter, the representative of industrial capitalism, is the enemy; in the other, it is we ourselves and our lack of knowledge that is the enemy. By framing the debate about synthetic biofuels in this manner, an all-or-nothing fight for the future, various ethical issues are highlighted (who makes money? who owns nature? who should be trusted?) and others implied (is capitalism evil? is science out of control?). The positions developed through the use of metaphors as ethics are a stark contrast. In the former deployment of the narrative we find 'profiteering industrialists are tinkering' with natural entities thereby implying an ethical standpoint that essentialises the organism, and to some degree the category of 'life', and reduces the practices of scientists that have been the focus of the ethical debate to the level of childish play. t reating the metaphor as ethics it is obvious that the et C is strongly anti-capitalist. in Venter's counter-narrative we find microbes are 'natural' solutions, a frame that highlights the 'organic' nature of the hardware and re-characterises Venter as in tune with the environment. t his is an ethical standpoint that supports research into synthetic biology, appeals to notions of working with nature rather than against it such that our global problems can be solved via green technological determinacy.

Conclusions

t he broad frames discovered in the corpus play across the binaries living/inanimate and synthetic/natural whilst highlighting the good or evil action of human scientists. t his is accomplished through the development of a computational metaphor that builds upon, but significantly alters, previous literary metaphors such as the 'book of life', and has two ethical consequences: 1) life is seen in a highly instrumental way which encourages us to focus on the producer of the product and not the product itself; and 2) the products are seen as designed and part of industrial processes, which facilitates claims to patentability. t he et C and the media coverage of their reports and comments plays into this metaphorical framing by implicating profiteering motives in the construction of these software/hardware products. t hey fuse the computational discourse with the second broad framing, a comic book narrative of tyranny, which poses Venter against mankind. Venter, though we wouldn't imply intentionally, counters this conceptualisation with his own comic book heroism. Whereas in the context of the programmatic metaphor the designed aspect of the organism was highlighted, it is the natural aspect that comes into play when the metaphorical frame turns ecological. n either of these framings exists independently, but they are not entirely compatible since they highlight particular features of the organisms for particular purposes, whether those be to close off fears or to highlight hopes.

A metaphorical struggle is taking place between various conceptualisations of synthetic biology and Craig Venter himself. We have shown, as others have, that certain ethical concerns are highlighted and others erased by the actors, e.g. the et C, in their metaphorical framings. h owever, by treating these metaphors as ethical statements in themselves we have been able to show that they not only shape ethical spaces but also make normative pronouncements on ethical issues. t his is important for any analysis of how scientists and other actors communicate science to the public. Perhaps more significantly it demonstrates that when journalists reproduce the metaphorical frames that their interviewees use, e.g. the programming metaphor, they themselves are making ethical pronouncements on the content of their articles. When they invent or play into metaphors of villainous capitalists and ecological heroes, they aren't presenting objectively; rather they are actively engaging in ethical debate with scientists and the public. h ow and why science communicators choose metaphors may have less to do with enabling understanding and more to do with their political and ethical disposition.

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ePilogue

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Chapter 15

Blame Francis Bacon: t he m etaphor of Progress and the Progress of m etaphor in Science

m egan a llyse

> o ne fact may have made itself clear to many readers to whom it was not so clear before – that all over the land is a strange new guild, the brotherhood of the observers and experimenters – restless questioners with chemic test and geologic hammers and sounding plummet and stupendous mathematic analysis – extorting Promethean secrets from earth and air and sky and ocean, and whose ceaseless activity is silently transforming the entire surface and substance of our modern life, and building up a new heaven and a new earth around us! (Anonymous 1860)

The science desk of the venerable *New York Times*, if you please. Circa 1860. ‘a nd people accuse us,’ modern science communicators might well retort, ‘of occasionally overstating the case.’ Indeed, the confluence of science and metaphor is old, as old as the days when science was nothing more *than* a metaphor, for where fire came from or why it rained or whom to blame when terrible things happened. Even now that we know where fire and rain come from, we’re still invoking Prometheus and Pandora and their distant descendents Frankenstein and Columbus. We cannot, it seems, do without metaphors in describing the world. But even as we acknowledge their indispensability, the endemic use of metaphor in the communication of science no longer seems as harmless as it once did. increasingly, as science, technology, politics and culture become further entwined, we are forced to pay closer attention to how we operate at the nexus of these powerful forces. i f metaphors are the linguistic bearers of our understanding of the world then surely it is worthwhile to ask where they come from, how they’re used and, perhaps most importantly, what effect they have on how we think and behave. Who, in other words, is this Prometheus person, and why is he always shoving a burning branch in our faces?

The contributors to this volume have addressed this question from a variety of perspectives. As philosophers, journalists, social scientists and press officers they have explored both the causes and effects of metaphors in communicating science. in doing so, they have illuminated two related strands of the relationship between science and metaphor. The first has to do with the metaphor of scientific progress itself, and the way in which it inevitably frames our understanding how science works and our expectations of what it can accomplish. The second is the use of metaphors within science, to convey specific ideas or propose new lines of inquiry. In concluding, therefore, we wish to briefly revisit these two strands and summarise some of their main features.

Francis Bacon and the metaphor of scientific progress

Most of us, writes scientist turned science journalist Kyla Dunn (Stossel 2001), tend to imagine scientific research 'as a long road trip to a known destination. The scientists are up front driving, while the rest of us sit in back and shout "Are we there yet?" at maddeningly frequent intervals.'[1]

While this 'science as a journey' metaphor resonates easily in today's culture, it is a comparatively modern understanding of how science works. In actuality, the idea of science as a vast, never-completed edifice constructed of 'bricks' of knowledge, contributed by scientists working in cooperation through the ages, was birthed, more or less virginally according to historian of science e dgar Zilsel (1945), by Francis Bacon in the 16th century. Before that, 'advancement' was how well your son was doing at school and 'progress' referred to the tours a sovereign might make of her kingdom (Bacon 1996). In reapplying these terms to the practice of scientific inquiry, Bacon engendered what might be the first overarching constitutive metaphor of science. 'Bacon's task', writes Michelle Le Doeuff, 'was to devise a concept of progress which would determine how that concept itself could become possible' (Le Doeuff 1991). For Bacon, the necessity of progress in science was linked with the ability of the scientific endeavor to relieve the suffering of man at the hands of nature (Bacon 1996). In 1864, as if to underscore the point, the historian T.H. Buckle announced that through exhaustive inductive reasoning he had conclusively demonstrated that the success of a civilization was intrinsically linked not to its moral development but its progress in science and technology. t he more science you had, the better your society.

Today, we have in many respects internalized this view that scientific progress is necessary to our society. a s Jasanoff points out, much of the governance of late-20th century Western democracies has been predicated on visions like those laid out by Vannevar Bush, the architect of the US's post-World War II scientific explosion, in his famous metaphor of science as the 'endless frontier.' 'in order to achieve [our] goals', Bush writes, 'the flow of new scientific information must be both continuous and substantial' (Bush 1945/1980). Like a shark in the sea of nature, if we stop swimming we are, in effect, dead. But keep moving forward and we will rule the ocean.

Indeed, we no longer have any means of speaking about the exercise of science that does not involve forward movement. We have scientific progress, 'a going

1 l est we be accused of misrepresentation, Dunn does go on to say that this is the *wrong* way to think about science.

on.' Scientific development, an 'unrolling or unfolding.' Scientific advancement, 'to move forward, to move against.' Even scientific research, 'to seek out, to search.' in this context, much of the language available to science communicators is in some senses prescribed. In reporting scientific work they can add variety by talking about pace. We invariably take steps, sometimes important steps, down avenues of research. Sometimes we leap forward. Sometimes we race. But they have little discretion when it comes to direction. We only very rarely, when things go very wrong, regress or backslide or retrace our steps. And if we talk of exploring, it had better be because we discovered something and not because we were out for a stroll.

Science communicators can try to place the work in context: it is leading us towards something. it brings our goal closer. t hey can measure our progress against milestones, or point out that a door has been opened to other avenues. But because, as all the journalists writing here are at pains to point out, science communication is just one of many streams of information competing for attention, the faster the better. l eaps sell better than steps, highways better than avenues and human immortality better than a nuanced understanding of the universe. if scientists are driving, science communicators seem invariably to be the ones sitting in the passenger seat, constantly turning around to say 'a lmost. We're almost there. Stop hitting your sister.'

Perhaps this is why the 'science as a journey' metaphor is noticeably more prevalent in biology, a field which is, as Turney remarks, already steeped in metaphor. o ur health, and biomedicine's effect on it, is the most intimate connection many of us have with science and the area where our expectations of its ability to 'relieve man's estate' are highest. in biomedical research, to which Dunn's metaphor originally referred, even steps and leaps are too slow. instead, we have a geometrically increasing series of 'breakthroughs.' Breakthroughs add a rather different dimension to the whole journey. What, after all, do we generally break through? Barriers? Enemy lines? Suddenly, we are not in the family minivan on an idyllic country holiday but the belly of a tank, battering through enemy fortifications while Lieutenant Media, sitting up top in his flack jacket, shouts down 'There goes another one! Not long now lads!' Perhaps some of us have been hit by enemy fire and Captain Science is desperate to get us to the Red Cross tent before it's too late. t hat explains the urgency.

Indeed, as Nerlich points out, breakthroughs are merely a part of a larger genre of 'health as a war zone' images where science is portrayed as leading the charge against nature and her many bacterial, microbic and viral minions. o f course, it makes sense. Face to face with the suffering and death of millions of people, many of whom are convinced that biomedical research can alleviate their pain, it hardly seems appropriate to point out that, in the words of cellular biologist r ichard Weinberg (2002), 'progress in biology is [usually] held back by experimental difficulties, inadequate instruments, poorly planned research protocols, inadequate funding, or plain sloppiness.' To do so invites the thought that this scientist, like South Korea's Hwang Woo-Suk, is simply a bad driver. We should leave him by the side of the road and pick someone new. Far better, for the profession of science as a whole, and thus the *eventual* relief of all that suffering, to imply that something, n ature herself, is trying her hardest to stop scientists from advancing. Everyone knows, after all, what happens to soldiers who question their orders and passengers who distract the driver or, perhaps, refuse to chip in for petrol.

But in using metaphors that facilitate this kind of scientific militarism, scientists, and science communicators, are merely advocating a conduit model of scientific information which suggests that scientists are driving because they are the only ones who know how. The truth is, all of us know how to drive, to some extent. We may not be certified on Mack trucks or jet airplanes but we know the basics. We are aware that going too slow means not getting anywhere and going too fast will probably cause us to crash into something. This is not knowledge we need imparted to us. Furthermore, we all have an interest, sometimes a very vested interest, in where we are going. a s murcott argues, from a vantage point that builds on ten years of scientific research and fifteen years of science journalism, science is no longer divine and science journalists are not a priesthood.

In truth, that kind of technocracy was probably exactly what Bacon had in mind when he invented scientific progress, but he did not have our knowledge of the potential consequences of unbridled scientific development. As Sarewitz (1996) points out, the history of the 20th century renders problematic the idea that social welfare is directly correlated to scientific progress per se. What matters is what we are progressing towards. And despite the many utopias and dystopias floating around the public sphere, the truth is that there is no known destination. Nobody actually knows where we are going. This makes it even more important, argues Rehmann-Sutter, that everybody – scientists, journalists, academics and laypersons alike – can become an equal participant in a healthy public sphere where we can make collective decisions about our direction of travel. Thanks to Bacon, we may have no choice but to move forward, but we do not have to do it through a war zone.

t hinking and feeling: Metaphors in science communication

Let us now take a step down from the lofty peaks of the history of scientific progress. Quite apart from the metaphor of science, much of this volume is devoted to the analysis of metaphors *in* science. Like so many aspects of social co-existence that we take for granted, metaphors receive the most attention when they 'go wrong'. When 'hype' leads to fraud and disillusionment. When interest groups exploit carefully chosen metaphors to advance ideological viewpoints. When scientists, whether intentionally or not, invite strategic interpretations of their work through the metaphors they use to communicate it. In such situations, it helps to distinguish two kinds of metaphor in science communication: thinking metaphors and feeling metaphors. o ne of the prime reasons for the enduring popularity of metaphors is that they remain the best way to mean what you say without saying what you mean. In differentiating between thinking and feeling metaphors, therefore, the first question that must be asked is, 'what do I mean by this analogy? a m i using it because i *think* about these two concepts in the same way? o r because i *feel* the same way about one as i do about another?

Take, for example, the frequent comparison of certain technologies to Frankenstein's monster. As a thinking metaphor, this analogy might suggest that this is a new technology created without much forethought by someone intelligent but socially misguided which is neither good nor bad but, being strange and unprecedented, is probably doomed to persecution and violent misuse by an unthinking and prejudiced society. It may, as Balmer and Herreman point out, cause us to think about where this technology has come from. Who created it, and why? What are our intentions for its use and do we have the power to enforce them? it highlights, in short, our responsibilities as a society, of both scientists and non-scientists, towards our own intellectual creations. a s a feeling metaphor, of course, it means 'it's horrible, drive it out of town with pitchforks.'

Whatever Mary Shelley's intentions, Frankenstein's monster is no longer available to us as a thinking metaphor. Through constant repetition, it has been quite thoroughly co-opted as a feeling metaphor designed to convince people that a certain technology is intrinsically dangerous to the preservation of civilized society and should be immediately 'killed off'. In general, feeling metaphors serve to encourage people to adopt a stance towards an area of science or a specific technology without thinking too much about it. Either because the author believes the complexity of the science exceeds their ability to explain clearly or because (s)he believes that feeling a certain way about this technology is right and necessary for the good of our society.

As an example, take two of the cases discussed in this volume. Comparing the interaction of non-native species in an ecological system to the failure of a nuclear power plant, or the continued evolution of a bacterial strain to the apocalypse, are not good thinking metaphors. Most of us think of nuclear 'meltdown' as a succession of cumulative technical failures, possibly compounded by operator error, which leads to the slow, painful deaths of a great many people and leaves the surrounding area uninhabitable. t his is not, we suspect, the view most of us have of the interaction between yellow crazy ants and scale insects on Christmas island. n or, no matter how strong the health impacts, is the mutation of infectious viruses beyond the capacity of our existing antibiotics to control them, really much like the destruction of human civilisation through the triumph of War, Famine, Pestilence and Death. t hese are not aids to comprehension; they are, as l arson and n erlich point out, linguistic megaphones through which scientists shout 'This is bad! Pay attention!' And in distributing them through media sources, no matter how many quotation marks are put around them, science journalists and communicators are, essentially, agreeing. This principle applies equally to the positive analogies, such as 'the book of life' or the 'American frontier', discussed by Hellsten. 'Even if you don't understand why,' they say, 'just take our word for it, this is a good thing.'

The point being, obviously, that all of us – scientists, journalists, editors and readers alike – should think twice when we encounter feeling metaphors. Why are we encouraging people, or being encouraged ourselves, to feel this way? What are the interests of the metaphor creator in causing these feelings? What is my interest in facilitating those feelings? a nd, perhaps most importantly, what are the consequences of this metaphor being a success? What does a world in which people actually feel like this look like? Does Hellsten's finding that scientists and public figures tend to use thinking-oriented metaphors with each other and feeling-oriented metaphors when talking to the public suggest that they are less interested in the public's understanding than in their support? a nd, if so, what does this say? t he central component of Jasanoff's 'technologies of humility' is not that we, as creators and distributors of scientific knowledge, should start going around in sackcloths and ashes, but that we should resist behaving as if our 'privileged' position gives us the right to decide what is best for everyone.

All of which could be taken as a blanket precept to suggest that properly 'objective' and ethical communicators of science should avoid feeling metaphors entirely, unless they have also taken up writing poetry on the side. Of course, in practice, things are not that simple. As Radford points out, the ability to make the reader feel is a pivotal factor in the success or failure of a journalist or media publication. Humans like to feel things. Partly because it's a key component of being human and partly, if we are honest with ourselves, because feeling is easier than thinking. If the science section of the newspaper receives so little attention, perhaps it is because there are other sources of information that engender emotion, even if it is only a sense of amused dismay at celebrity antics, and do so at a very low intellectual cost to the reader. No matter how firm our belief that the contents of scientific exploration are far more important to society than Prince h arry's romantic interludes, the reality of the situation seems to be that we cannot convince everyone else of this fact unless we can make them feel at least as much about one as they do about the other. How, then, do we make them feel, without telling them *what* to feel?

t he second complicating factor is that people do not have neat divisions in their minds between what they think and what they feel. What seems like a perfectly good thinking metaphor in the lab or the reporters' bullpen may become an absolute storm of controversy in the public sphere because objects and ideas do not exist in isolation. t he metaphor of genetic barcoding, discussed by both Strauss and l arson, is an excellent example of this phenomenon. inside the lab, or the supermarket, it makes perfect sense. A string of numbers, a string of letters, a specific brand of soup, a specific species of squid. Simple, accurate, ubiquitous. But of course, and perhaps this should have been obvious by 2003, barcodes have a whole host of cultural meanings independent of their ability to distinguish between brands of soup. t o many people, they signify standardization and mass production, commodification and even dehumanization. It is useless to protest that species barcoding has no application to humans, or that distinguishing between closely related species of animals should give us more appreciation for the diversity of life and not less, when the application of barcodes to living things has already been implicated in the rise of o rwell's Big Brother and, at its most emotive, concentration camps. h ebert may have chosen the metaphor because he wanted people to think about taxonomy in a certain way, but he failed to take into account how they feel about barcodes.

Commentators have historically blamed 'failures' of science communication, as embodied by public outrage or rejection of a certain technology, on inaccuracies in reporting or a lack of understanding on the part of 'the public'. Even journalists have frequently attributed the problem to their profession's historical application of 'false balance' in science reporting; allowing interest groups or non-credible scientists to inject misleading feeling metaphors into the public sphere in a way that grants them equal status with mainstream scientific information. This is the kind of problem that Fox and the Science Media Centre were set up to address and certainly an important component of improving public debate on scientific issues. But, as Nesbit points out, accurate scientific data are only the 'first frame' for any public debate; it is within the 'second frame' of personal ideology, lived experience and self-interest that the policy decisions which directly impact the conduct of science and its effect on individuals will be made. Intentional thinking and feeling metaphors can be a powerful force in shaping this second frame, but their use will only be ethical, and in the long term effective, if science communicators are honest and open about the interests and worldviews they are designed to support.

Conclusion

Questions about the means and ends of science communication are not new and are unlikely to get old. Science and its products are so intrinsically a part of our daily lives that the importance of deepening our understanding of where it came from and, perhaps more importantly, where it is going, seems increasingly uncontroversial. But that understanding is impossible without a working knowledge of what the available science *is* and what it means. t his volume, at its core, has concerned itself with where we get that knowledge, who provides it, and how it is presented to us. We have argued that the use of metaphor to mediate, constitute, frame and situate such knowledge is both inescapable and frequently problematic. In order to improve our understanding of the process of knowledge transfer, we have tried to facilitate a better shared understanding of our own metaphors and, most importantly, their effects. This process, like all intellectual inquiry, is ongoing. It did not begin with this volume and, we hope, it will not end here.

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index