ICONS OF EVOLUTION

A STUDENT STUDY GUIDE

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See the companion video by ColdWater Media, available at www.coldwatermedia.com

Published in the United States by ColdWater Media • PO Box 400 • 300 General Palmer Dr • Palmer Lake, CO 80133
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INTRODUCTION

This study guide is intended to accompany the video "Icons of Evolution," by ColdWater Media. Parts of the video are based on the book of the same name by biologist Jonathan Wells.

An "icon of evolution" is an image or symbol that is thought to represent key evidence for Darwin's theory of evolution. The book and video are about some icons of evolution that are commonly found in biology textbooks. Like the book and video, this guide is not intended to replace the biology curriculum, but only to supplement it.

According to Linus Pauling, winner of two Nobel prizes, science is the search for truth. Scientists try to determine whether their theories are true by comparing them with evidence from nature. Theories that are consistent with the evidence may be regarded as true — but only tentatively, since contrary evidence may later be found. Theories that turn out to be inconsistent with the evidence must be revised or rejected — otherwise they are myths rather than science. In their search for truth, scientists must be careful not to distort the evidence to fit their theories.

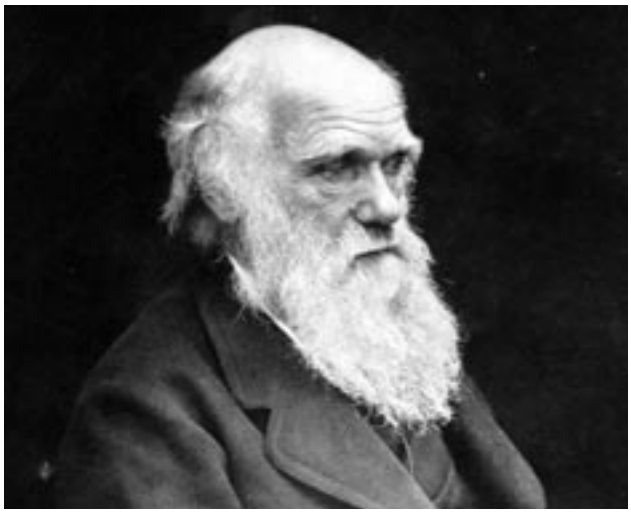
According to Darwin's theory of evolution, all living things are descended with modification from one or a few common ancestors. There are thus two basic elements to the theory: common ancestry, and the mechanisms responsible for modification. The primary mechanism of evolution proposed by Darwin was natural selection acting on random variations. Like all other scientific theories, Darwin's theory of evolution must be compared with evidence to determine whether it is true. This guide is about some of that evidence.

1. Why is it important for scientists to compare theories with evidence?

2. What are the two basic elements of Darwin's theory of evolution?

3. What does "icon of evolution" mean?

THE THEORY OF EVOLUTION: AN OVERVIEW



Charles Darwin (1809-1882) as an old man.
Courtesy of the University of Oklahoma
History of Science Collections

Charles Darwin is the name most often associated with the theory of evolution. Several decades after a five-year voyage aboard the British survey ship H.M.S. Beagle, during which he studied wildlife in several parts of the world, Darwin wrote two very influential books: *The Origin of Species* in 1859, and *The Descent of Man* in 1871. Darwin proposed that all living things, including human beings, are descended from one or a few original forms that lived in the distant past, and that their subsequent modification has been due principally to natural selection acting on random variations.

Darwin had no direct evidence for natural selection, so he argued mainly from the analogy of domestic breeding, or artificial selection. A breeder can modify farm animals or crops over the course of many generations by allowing only those with desirable traits to reproduce. Similarly, Darwin argued, the conditions of life can modify wild populations by allowing only those with favorable traits to leave offspring — except that in nature, traits are favorable not because they please a human breeder but because they enable an organism to survive in the

competition for limited resources. Although domestic breeders can produce only minor changes in existing species, Darwin believed that over millions of years natural selection could produce new species with dramatically new features.

Missing from Darwin's theory was an explanation of how traits are inherited or how new ones originate. Unknown to Darwin, Austrian monk **Gregor Mendel** described in the 1860s how some traits in plants are inherited according to regular laws. In the early twentieth century, Mendel's laws were updated and combined with the mutation theory of Dutch botanist **Hugo DeVries** to become the modern science of genetics. After 1953, genes became identified with sequences in DNA molecules, and mutations with random changes in those sequences.

Supplemented by genetics, Darwin's theory became known as "neo-Darwinism." According to neo-Darwinism, organisms are products of their genes; natural selection modifies organisms over many generations by preserving favorable genes and eliminating harmful ones; and new genes are occasionally added by random DNA mutations.

Nowadays, when asked about the evidence for neo-Darwinism, most people — including most biologists — list the same few examples. These include similarities in the embryos of vertebrates (animals with backbones), finch beaks that became larger after a drought, an extra pair of wings in mutant fruit flies, antibiotic resistance in bacteria, skeletal similarities ("homologies") in vertebrate limbs, a fossil record used to illustrate Darwin's branching tree of life, and a 1953 experiment designed to simulate the origin of life's building blocks on Earth.

Three of these "icons of evolution" (embryos, homologies and fossils) are used as evidence for common ancestry; three others (finches, mutant fruit flies, and antibiotic resistance) are used as evidence for modification due to natural selection and mutation. One (the 1953 origin-of-life experiment) is used as evidence for how evolution got started in the first place. The reason these icons of evolution are so well known is that they are found in most of the textbooks used in high school and college biology courses. In the next seven sections, this guide compares these icons with the actual scientific evidence.

4. What were Darwin's two most important books?

5. Why did Darwin argue by analogy from domestic breeding?

6. What is "neo-Darwinism"?

7. List seven of the icons of evolution commonly found in biology textbooks.

SECTION 1: HAECKEL'S EMBRYOS

1-1 DARWIN'S STRONGEST EVIDENCE

You should know why Darwin considered embryos to be the best evidence for his theory, and how Haeckel's embryo drawings have been used to support it.

An embryo is an animal in the earliest stages of its development. Darwin wrote in *The Origin of Species* that "the embryos of the most distinct species belonging to the same class are closely similar, but become, when fully developed, widely dissimilar." Because Darwin believed that embryos retrace their evolutionary history in the course of their development, he believed that similarities among embryos from different classes point to their descent from a common ancestor, or progenitor. In fact, Darwin believed that the earliest stages of embryos in any group of animals would "show us, more or less completely, the condition of the progenitor of the whole group in its adult state." He wrote to a colleague in 1860 that he considered this "by far the strongest single class of facts in favor of" his theory of evolution.

In the 1860s German biologist **Ernst Haeckel** (pronounced "HEK-uhl") made drawings of embryos from five of the seven classes of vertebrates (animals with backbones) to illustrate Darwin's point. In Haeckel's drawings, the earliest stages are almost identical *(top row in Figure 1-1)*, and the embryos become noticeably different only as they mature into a fish, salamander, turtle, chick and various mammals *(bottom row in Figure 1-1)*. Haeckel, like Darwin, believed that the earliest stages resemble the common ancestor of all vertebrates.

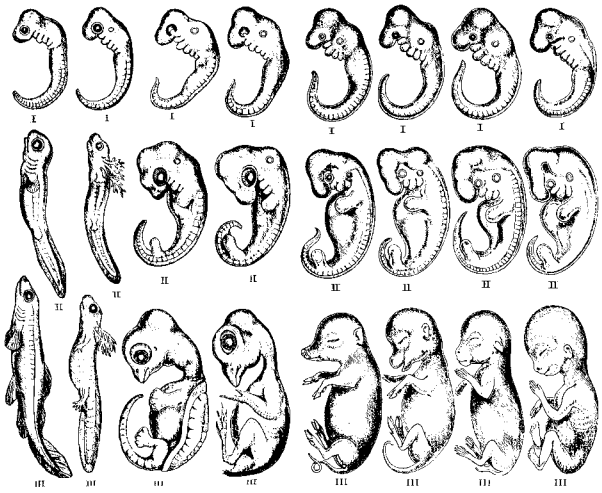


Figure 1-1: A popular version of Haeckel's drawings of vertebrate embryos.

1. Why did Darwin consider similarities in early embryos to be the strongest evidence for his theory?

2. How do Haeckel's drawings appear to support Darwin's theory?

1-2 HAECKEL'S MISREPRESENTATION

You should know how Haeckel's drawings distort the actual evidence.

Soon after Haeckel's drawings were published, his scientific colleagues criticized him for misrepresenting the evidence. It turns out that Haeckel distorted the embryos in the top row to make them look much more similar than they really are *(Figure 1-2)*. Furthermore, he included only vertebrates that helped him to make his point. For example, to represent amphibians he used a salamander rather than a frog, which would have looked quite different *(middle row, second column from the left in Figure 1-2)*. Haeckel also included four mammals from the same subclass; the embryos from other subclasses of mammals (such as the duck-billed platypus or the kangaroo) do not look as similar. Finally, Haeckel distorted the evidence in his favor by entirely omitting two of the seven classes of ver-