


EVOLUTION

What the Fossils Say and Why It Matters



Donald R. Prothero



Over the past twenty years, paleontologists have made tremendous fossil discoveries, including fossils that mark the growth of whales, manatees, and seals from land mammals and the origins of elephants, horses, and rhinos. Today there exists an amazing diversity of fossil humans, suggesting we walked upright long before we acquired large brains, and new evidence from molecules that enable scientists to decipher the tree of life as never before. The fossil record is now one of the strongest lines of evidence for evolution, and yet it continues to come under attack by present-day creationists and advocates of Intelligent Design for not supporting the theory of biological evolution. With this engaging and richly illustrated book, leading paleontologist Donald R. Prothero sets the record straight.

Prothero weaves an entertaining though intellectually rigorous history out of the transitional forms and series that dot the fossil record. Beginning with a brief discussion of the nature of science and the "monkey business of creationism," Prothero tackles subjects ranging from flood geology and rock dating to neo-Darwinism and macroevolution. He covers the ingredients of the primordial soup, the effects of communal living, invertebrate transitions, the development of the backbone, the reign of the dinosaurs, the mammalian explosion, and the leap from early primates to *Homo sapiens*. Prothero pays particular attention to the recent discovery of "missing links" that complete the fossil timeline and the controversy among contemporary scientists over the mechanisms of evolution.

(continued on back flap)

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and Why It Matters

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Donald R. Prothero
With Original Illustrations by Carl Buell

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*To my friends and mentors,
Niles Eldredge and the late Stephen Jay Gould,
who transformed both paleontology and evolutionary biology*

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Foreword

Why People Do Not Accept Evolution

Michael Shermer

Thomas Henry Huxley proclaimed the *Origin of Species* to be “the most potent instrument for the extension of the realm of knowledge which has come into man’s hands since Newton’s *Principia*.” Ernst Mayr, arguably the greatest evolutionary theorist since Darwin, asserted that the *Origin of Species* triggered the greatest paradigm shift in the history of science. The late paleontologist Stephen Jay Gould, who inherited Huxley’s mantle as public intellectual, called the theory of evolution one of the half dozen most important ideas in the entire history of Western thought. The philosopher of science Daniel Dennett called evolution the most dangerous idea in the history of science.¹

If Darwin’s theory of evolution is so profound and proven, why doesn’t everyone accept it as true? Before we review the reasons, please note that I use the verb “accept” instead of the more common expression “believe in.” Evolution is not a religious tenet to which one swears allegiance to or belief in as a matter of faith. It is a factual reality of the empirical world. Just as one would not say, “I believe in gravity,” one should not proclaim, “I believe in evolution.” So why do so many people not accept evolution? I suggest that there are at least seven reasons.

1. *Misunderstanding of evolutionary theory.* Because of the controversy generated by the evolution-creation debate, the subject is often not included in science curricula, or if it is, teachers opt out of teaching it to avoid tensions and conflict with administrators and parents.²

2. *A general fear that science is a threat to religion.* This falls under the rubric of what I call the *conflicting worlds* model of science and religion, where one is forced to choose one over the other, which I contrast with the *same worlds* model in which an attempt is made to use science to prove religious tenets, and the *separate worlds* model, where science and religion occupy entirely different domains.³

3. *A specific fear that evolutionary theory is a threat to religion.* For specific religious tenets, such as that of the age of the earth or the sequence of creation in Genesis, science and religion are in conflict. Fortunately, most of the world’s religions are flexible enough to adjust to the ever-changing findings of science and read their origin myths as allegory.⁴

4. *The fear that evolution degrades our humanity.* After Copernicus toppled the pedestal of our cosmic centrality, Darwin delivered the coup de grâce by revealing us to be “mere” animals, subject to the same natural laws and historical forces as all other organisms.

5. *The equation of evolution with ethical nihilism and moral degeneration.* The reasoning behind this fear runs along these lines: Evolution implies that there is no God, so belief in the theory of evolution leads to atheism; without a belief in God there can be no morality or meaning; without morality and meaning there is no basis for a civil society; without a civil society we will be reduced to living like brute animals. Such illogic was voiced in 1991 by the neo-conservative social commentator Irving Kristol: “If there is one indisputable fact about the

human condition it is that no community can survive if it is persuaded—or even if it suspects—that its members are leading meaningless lives in a meaningless universe.”⁵ Nancy Pearcey, a fellow of the Discovery Institute, in a briefing on Intelligent Design before a House Judiciary Committee of the United States Congress, echoed similar sentiments when she quoted from a popular song that urged “you and me, baby, ain’t nothing but mammals so let’s do it like they do on the Discovery Channel.” Pearcey went on to claim that since the U.S. legal system is based on moral principles, the only way to generate ultimate moral grounding is for the law to have an “unjudged judge,” an “uncreated creator.”⁶

6. *The fear that evolutionary theory implies we have a fixed or rigid human nature.* This is a variant of genetic determinism and is a criticism leveled against sociobiology and evolutionary psychology because of the deterministic implication that we are resistant to political reforms and economic reapportionment policies. Interestingly, the first five reasons above tend to arise from the political right because of its strong religious conservative bent that sees evolutionary theory as a challenge to fundamental religious doctrines; this last reason surfaces from the political left because of its strong liberal bent that sees evolutionary theory as a challenge to their fundamental political doctrines. I call these positions *conservative creationism* and *liberal creationism*, respectively.

7. *The equation of evolution with mutual struggle instead of mutual aid.* An especially odious myth about evolution is the presumption that animals and humans are inherently selfish and that nature, in Tennyson’s memorable description, is “red in tooth and claw.” After *The Origin of Species* was published, the British philosopher Herbert Spencer immortalized natural selection in the phrase “survival of the fittest,” one of the most misleading descriptions in the history of science that has been embraced by social Darwinists ever since, applying it inappropriately to racial theory, national politics, and economic doctrines. Even Darwin’s bulldog, Thomas Henry Huxley, reinforced what he called this “gladiatorial” view of life in a series of essays, describing nature “whereby the strongest, the swiftest, and the cunningest live to fight another day.”⁷

This view of life need not have become the dominant one.⁸ In 1902 the Russian anarchist and social commentator Petr Kropotkin published his rebuttal to Spencer and Huxley in his book *Mutual Aid*. Calling out Spencer by phrase, for example, Kropotkin notes: “If we . . . ask Nature: ‘who are the fittest: those who are continually at war with each other, or those who support one another?’ we at once see that those animals which acquire habits of mutual aid are undoubtedly the fittest. They have more chances to survive, and they attain, in their respective classes, the highest development of intelligence and bodily organization.” In numerous trips to the wild hinterlands of Siberia, Kropotkin discovered that animal species there were highly social and cooperative in nature, an adaptation for survival that he deduced played a vital role in evolution. “In the animal world we have seen that the vast majority of species live in societies, and that they find in association the best arms for the struggle for life: understood, of course, in its wide Darwinian sense—not as a struggle for the sheer means of existence, but as a struggle against all natural conditions unfavourable to the species.”

Kropotkin may have been an anarchist but he was no crackpot when it came to human nature. “There is an immense amount of warfare and extermination going on amidst various

species," he admitted, noting that "the self-assertion of the individual" is the other "current" in our nature that must be recognized. However, he added, "there is, at the same time, as much, or perhaps even more, of mutual support, mutual aid, and mutual defense. . . . Sociability is as much a law of nature as mutual struggle."⁹

It is a matter of balancing these dual currents of selfishness and selflessness, cooperation and competition, greed and generosity, mutual struggle and mutual aid. That this view of life was eclipsed by that of Spencer and Huxley probably has more to do with where they were developed: the more competitive economy of England versus the more egalitarian economy of Russia.¹⁰

All seven of these causes feed into that peculiar American movement known traditionally as creationism, updated as creation-science, and most recently mutated into Intelligent Design (I.D.), all of which are brilliantly encapsulated and devastatingly dismantled by the geologist and paleontologist Donald Prothero in the best book ever produced on the subject. I've known Don since the early 1990s when I took an active role investigating the claims of the creationists and publicly airing them in numerous forums, including in articles, essays, opinion editorials, books, lectures, and debates. Throughout this odyssey Don has been my co-pilot, directing my efforts, focusing my concentration, checking my facts, and guiding me through the labyrinth of scientific sources, of which he is the master. I am delighted beyond words that Dr. Prothero has taken time away from his primary paleontological research to put down on paper all he knows about this multifarious movement. It's a thankless job but someone has to do it, and the world is a better place for Don's efforts.

Although creationism and I.D. are, beyond doubt, a social, political, and especially religious movement, because claims are made that are purportedly based on sound science, at some point in the debate these claims must be answered point for point, and it is here where Prothero really shines. In particular, Don's visual presentation of the fossil and genetic evidence for evolution is so unmistakably powerful that I venture to say that no one could read this book and still deny the reality of evolution. It happened. Deal with it.

¹ Huxley quoted in Frank Sulloway, *Born to Rebel* (New York: Pantheon, 1996); Ernst Mayr, *Growth of Biological Thought* (Cambridge: Harvard University Press, 1982); Stephen Jay Gould, *The Structure of Evolutionary Theory* (Cambridge: Harvard University Press, 2000); Daniel Dennett, *Darwin's Dangerous Idea* (New York: Simon and Schuster, 1996).

² A 2001 Gallup poll, for example, found that 66 percent of Americans considered themselves to be "uninformed" about evolution.

³ Michael Shermer, *Why People Believe Weird Things* (New York: Henry Holt/Times Books, 1997), 137–38. Consider the results of a 1995 Gallup poll showing that 90 percent of Americans believe in heaven, 73 percent believe in hell, 79 percent believe in miracles, 72 percent believe in angels, and 65 percent believe in the Devil. It is not surprising that most Americans don't accept the basic tenets and methods of science when so many still hold fifteenth-century views of the world. Gallup surveys can be found at www.gallup.com.

⁴ According to a June 2007 Gallup poll, 43 percent of Americans agree with the statement "God created human beings pretty much in their present form at one time within the last 10,000 years or so," 38 percent prefer a blended belief that "Human beings have developed over millions of years from less advanced forms of life, but God guided this process," and only 14 percent accept the standard scientific theory that "Human beings have developed over millions of years from less advanced forms of life, but God had no part in this process." Gallup surveys can be found at

www.gallup.com. A 2005 poll by the Pew Research Center found similar results, with 42 percent of those surveyed holding strict "creationist" views that "living things have existed in their present form since the beginning of time." Pew survey data at <http://people-press.org/reports/display.php3?ReportID=254>.

⁵ Kristol, quoted in Ron Bailey, "Origin of the Specious," *Reason* (July 1997).

⁶ The three-hour briefing was held on May 10, 2000. Pearcey, quoted in David Wald, "Intelligent Design Meets Congressional Designers," *Skeptic* 8.2 (2000): 16–17.

⁷ Stephen Jay Gould, "Kropotkin was no Crackpot," *Natural History* (July 1988): 12–21.

⁸ Peter Corning, "Evolutionary Ethics: An Idea Whose Time Has Come? An Overview and an Affirmation," *Politics and the Life Sciences* 22.1 (2003): 50–77.

⁹ Petr Kropotkin, *Mutual Aid: A Factor in Evolution* (London: Heinemann, 1902).

¹⁰ Daniel P. Todes, "Darwin's Malthusian Metaphor and Russian Evolutionary Thought, 1859–1917," *Isis* 78.294 (1987): 537–51.

Sit down before a fact as a little child, be prepared to give up every preconceived notion, follow humbly wherever and to whatever abysses nature leads, or you shall learn nothing.

—Thomas Henry Huxley

The Bible tells you how to go to Heaven, not how the heavens go.

—Pope John Paul II

To the Reader: Is Evolution a Threat to Your Religious Beliefs?

Speak to the earth and it shall teach thee.

—Job 12:8

Many people find the topic of evolution and religion troubling and confusing. Some were raised in very strict churches that preached that evolution is atheistic and that to even think about the evidence of evolution is sinful. Fundamentalists have long tried to drive a wedge between traditional Christians and science, arguing that their interpretation of the Bible is the only one and that anyone who accepts the evidence for evolution is an atheist.

But this is not true. The Catholic Church, along with most mainstream Protestant and Jewish denominations, has long ago come to terms with evolution and accepted it as the mechanism by which God created the Universe. The Clergy Letter Project includes the signatures of more than 10,000 ministers, priests, and rabbis in the United States who accept evolution and do not view it as incompatible with religious belief. A number of studies have shown that about fifty percent of active scientists (Larson and Witham 1997) are also devoutly religious, including many of the prominent figures in evolutionary biology (Francisco Ayala, Kenneth Miller, Theodosius Dobzhansky, Francis Collins, and many, many others) and paleontologists (such as Peter Dodson, Richard Bambach, Anne Raymond, Mark Wilson, Patricia Kelley, Daryl Domning, Mary Schweitzer, and Simon Conway Morris), and they resent being called atheists by fundamentalists. As the late Stephen Jay Gould pointed out in his book *Rocks of Ages: Science and Religion in the Fullness of Life*, science and religion can be seen as nonoverlapping but equally valid means of understanding the world around us, and neither should encroach upon the domain of the other. Science helps us understand the natural world and the way it works, but it does not deal with the supernatural, and it does not make statements of what *ought* to be, as do morals and ethics. Religion, on the other hand, focuses on the supernatural and transcendent, with strong emphasis on the moral and ethical rules that humans should follow, but it is not a guide to understanding the natural world. When science tries to proscribe morals or ethics, it falters; when religion tries to interfere with our understanding of the natural world, it overreaches. For example, when Copernicus and Galileo showed that the Earth is not the center of the Universe, the Church eventually had to recant its error and regret its persecutions.

If you find yourself puzzled by all this confusion and wondering whom to believe, I welcome you to read these pages with an open mind. The fundamentalists have long been spreading myths and misconceptions and denying the self-evident facts about the fossil record. But they have no published research on fossils in peer-reviewed scientific journals, so they are no more qualified to write about fossils than they are qualified to write about auto mechanics or music theory. As a working paleontologist with firsthand familiarity with many of the fossils described here, I can testify and bear witness from personal experience that what I tell you about the fossil record in this book is based largely on my own observations and experience. Unlike the creationists, I have seen and studied many of the fossils discussed

in this book, and in many cases, I have done the basic scientific data collection and published the research myself. I hope that whatever your religious faith, you will let the fossils speak for themselves and not be tricked by the creationists' distortions or the false premise that to accept evolution is tantamount to atheism. Indeed, a scientific view of the earth and life is inspirational by itself. To many religious scientists and other people, the amazing motions of the planets, birth and death of stars and galaxies, and transformations of life are even more transcendent and awe inspiring than the narrow, literalistic view of the Universe peddled by extremists.

Prologue: Fossils and Evolution

It has been asserted by some writers who believe in the immutability of species that geology yields no linking forms. This assertion is certainly erroneous. . . . What geological research has not revealed is the former existence of infinitely numerous gradations connecting nearly all existing and extinct species.

—Charles Darwin, 1859

Most people think that the idea of evolution came from studying the fossil record. Although it is true that the change in fossils through time was well established by 1805, none of the early naturalists who studied fossils were driven to the notion of evolutionary change. The leading paleontologist of his time, Baron Georges Cuvier of France, did not accept the wild evolutionary speculations of his peers, such as Lamarck and Geoffroy, and used the fossil record to criticize these evolutionists. Early nineteenth century ideas about evolution came strictly from living organisms, and paleontology and fossils played little or no role in the debate.

When Darwin published *On the Origin of Species* in 1859, his arguments were based almost exclusively on the evidence from living organisms. Darwin spent two entire chapters appearing to apologize for the incompleteness of the fossil record and for the seeming lack of support it offered for his radical new idea of evolution. Actually, if you read those chapters closely, Darwin very cleverly convinces the reader that the fossil record is exactly as one would expect, given the processes of geology and the vast expanses of time that were already accepted for the age of the earth. In the second of the two chapters, he argues convincingly that the fossil record, as imperfectly known as it was back then, is still strongly supportive of his ideas.

But if the fossil record was not much help to Darwin in 1859, it soon became his chief line of evidence. Only a year after his book was published, the first specimens of the transitional fossil *Archaeopteryx* were found in Germany, and soon the British Museum had spent a fortune to acquire the first decent skeleton of this classic fossilized transition between birds and reptiles. In the 1870s, American paleontologist Othniel C. Marsh laid out a remarkable series of horse fossils that demonstrated how the entire lineage grew from a small dog-sized form with three or four toes to our modern racehorse. Soon other examples of evolutionary transitions in the fossil record were being described and published, and by 1900, some of the first fossils that belong to our family, but not our species ("Java Man," now known as *Homo erectus*), were discovered as well. The early twentieth century brought an incredible explosion of paleontological discoveries as the great museums mounted expeditions to the western United States and Canada, Asia, and Africa to secure great dinosaur skeletons for their exhibit halls, again producing further evidence of evolution in the fossil record.

But the past 20 years have produced some of the greatest discoveries of all, including incredible fossils that show how whales, manatees, and seals evolved from land mammals, where elephants, horses, and rhinos came from, and how the first backboned animals evolved.

We now have an amazing diversity of fossil humans, including specimens that show that we walked upright on two feet almost 7 million years ago, long before we acquired large brains. In addition to all this fossil evidence, we have new evidence from molecules as well that enables us to decipher the details of the family tree of life as never before.

Although scholars in 1859 may have considered Darwin's evidence from fossils weak, this is no longer true today. The fossil record is an amazing testimony to the power of evolution, with documentation of evolutionary transitions that Darwin could have only dreamed about. In addition, detailed studies of the fossils have even changed our notions about how evolution works and have fueled a lively debate in evolutionary biology about the mechanisms that drive evolution. The fossil record is now one of the strongest lines of evidence for evolution, completely reversing its subordinate status only 150 years ago. Instead of the embarrassingly poor record that Darwin faced in 1859, we now have an embarrassment of riches.

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