# ONE

# SCIENCE AND RELIGION

A lot of disagreements between people are due to honest emphasis on mutually exclusive propositions, both of which have clear value. Examples include social responsibility versus personal liberty, or freedom of speech versus the protection of minorities. In other cases, one party to a debate is just plain wrong, misinformed, or invested in error for extraneous and/or personal reasons. This includes the "divine right of kings" and "separate but equal" racial segregation. Society makes its way along the centuries by recognizing, and dispensing with, the erroneous (e.g., divine right) while building up institutions that can justly scrutinize the real debates, hopefully reaching the right decision more often than not.

The current debate between science and religion, in particular discussions of evolution and public education in the United States, is mostly a phenomenon of the erroneous sort. Some opinions of the partisans, while zealous in their delivery, are just plain wrong. However, making things more complicated is the fact that the "plain wrong" errors are committed by more than one party. On the one hand, the idea that the natural world around us does not teem with evidence in support of Darwin's theory of evolution, that humanity does not share common ancestry with other forms of life on Earth via the mechanism of descent with modification, is profoundly mistaken. You, I, and the rest of humanity are so part of the Tree of Life, this book is to help you count the ways. Equally wrong is the notion that acceptance of this evidence of biological evolution spells doom to a religious worldview (it

doesn't), or that Darwin told us anything definitive about the origin of life or how we could be good atheists (he didn't).

Speaking as someone with an academic perspective, who studies evolution for a living and is daily amazed at its explanatory prowess, the hard part of this debate is understanding why so many decent people out there find biological evolution so threatening. What is it about Darwinism that keeps otherwise honest, open-minded people from embracing the remarkable principle that explains—biologically—how they got their five fingers, arched foot, and hearing bones, as opposed to their pet frog's short backbone, long legs, and quiet demeanor? We—meaning not just card-carrying evolutionary biologists but anyone who's read the literature attentively—know with some precision the details behind many of the biological changes between groups of animals. We know not just in terms of the actual record of intermediate forms, both living and fossil, but also in terms of development and genetics. We know this so well that a geneticist who's never seen a fossil before in her life can come up with roughly the same estimate of the pattern of shared ancestry among animals with a backbone (vertebrates) as a paleontologist, using a completely different body of evidence.

I want to spend time in this book sharing with you in a simple, straightforward way a few of the well-documented cases that make Darwinian evolution so compelling. These concern facts and ideas that every biology teacher in every school should know, and they (you) should also know that such ideas do not have fatal implications for a principled, religious worldview. You've probably heard at some point that evolution and religion are fundamentally incompatible. Ironically, the extremists who advance opposite viewpoints on God versus Darwin agree entirely with one another on this point.[1] Nevertheless, it is a matter of simple, empirical fact that practicing evolutionists are not necessarily atheists. Even some who are atheistic recognize that pitting God against Darwin is a mistake and that the two do not comprise an either–or proposition. There have been tensions between religion and science in many quarters, but there have been many first-class evolutionary biologists who are agnostic (like Stephen Jay Gould) or very religious (like Francis Collins) who do not see a necessary conflict between a religious worldview and a materialist orientation of modern science.

In the coming pages, I'll describe in some detail what I mean by the phrase "materialist orientation of modern science." I'll also describe in this initial chapter how Darwinian natural selection does not address questions of ultimate meaning and purpose in existence, nor does it have to. But it does explain a lot of the *how* relating to life's diversity once it began, a beginning that Darwin himself attributed to the Creator (yes, God). Do you vote, pay taxes, or educate young people? If so, then you must know at least some

of the factual basis of the Darwin–Wallace theory of evolution, and how it has stood up to thousands of discoveries and scientific tests since it was first published in 1858. This includes a description in Chapter 2 of how evolutionary biology qualifies as a historical science in which hypothesis testing plays a central role, and how evolution by natural selection logically leads to a variety of specific predictions concerning common descent, geological time, the fossil record, the development of living organisms, and molecular biology—topics explored in later chapters.

The fossil record is an important line of evidence supporting the mechanisms of Darwinian evolution. However, it is entirely possible to make a strong case for evolution without recourse to the data from extinct life, and we'll do so in Chapter 3. Of course, when one does examine the fossil record, as any reasonable observer is obliged to do and as we'll do in Chapters 4–8, the case for natural selection as a mechanism behind life's diversity becomes even stronger. Chapters 9 and 10 detail some of the molecular biological agreement with other lines of evidence, agreement that fits specific predictions made by the theory of evolution. Chapters 11 and 12 conclude the book with a discussion of probability, and how claims of impenetrable complexity in biology are now, as they always have been, an inadequate substitute for understanding the mechanisms responsible for the emergence of biological diversity.

## DARWINISM, AGENCY, AND CAUSE

When the United States celebrated its two-hundredth birthday, my first-grade teacher, Miss Lee, sent me to deliver a message to her colleague down the hall, Mrs. Sanfrantello. When I realized that in order to deliver this message I had to enter the second-grade homeroom, I was dumbstruck. I could barely imagine how these advanced, civilized creatures would receive a puny first-grader like me into their midst. Fortunately, when I arrived they were occupied elsewhere and their room was empty except for Mrs. Sanfrantello, working at her desk. "Come in, honey," I heard as I poked my six-and-one-half-year-old face through the open doorway. The empty room (I didn't realize anything in that school could be so quiet) accentuated the sense of awe with which I entered; it seemed to me as a huge, cavernous cathedral, echoing with my every footfall. Mrs. Sanfrantello sat at her desk opposite the entrance, and walking up to her with Miss Lee's message seemed to take an eternity as I marveled at the pupils' desks, which came with integrated rulers—further proof of the heady intellectual climate that characterized this center of elementary-school culture. For days after this experience, I could hardly believe that I had actually been in the same room as second-graders!

A few months later, when I sat in this room as a second-grader myself, the integrated rulers really were no big deal, and the room turned out to be the same size as my first-grade classroom. Somehow the sense of awe had completely vanished.

It's possible that some people out there view "science" in a similar fashion as I saw the second grade at the age of six. This is not due to their child-like naïveté, but only because they've been busy with other things and haven't yet taken the time to look into this subject. Prior to being in it myself, I knew little about the second grade, and I attributed to it all sorts of capacities that it didn't actually have. I certainly could not envision myself as part of it. Yet this institution was host to the same sort of kids as me. Any differences between the first and second grades were of degree, not kind.

"Science" differs in a similar fashion from the plain and simple common sense that most people apply regularly in life. It is the fundamental, principal ingredient in the scientific pursuit of knowledge. To turn common sense into science, one simply adds a variety of accessory facts, a more rigorous way of framing questions, careful data collection and assessment of probability, and availability of relevant data in a coherent format to others, and voilà. You're a scientist. Now this is not to minimize the training involved. After all, just using our common sense, the Earth does look flat when looking around while standing in a parking lot. Such a perspective does not allow for collection of enough "accessory facts."

There's nothing magical about the scientific study of biological history or about tracing the evidence of life's evolution. Strains of flu virus can evolve just as speedily among first-year business students as among zoology undergrads—and both are capable of observing, learning about, and suffering from such phenomena. In fact, an appreciation of even just a few of these readily available facts is enough to make a very compelling case for Darwinian evolution—meaning descent with modification over long periods of time.

The phrase "descent with modification" encapsulates Darwin's idea. Attributes of plants and animals have the capacity to be inherited across generations; these attributes may change slightly from one generation to the next; more offspring are produced than can actually survive; some members of one generation may be particularly good at contributing their offspring to successive generations. Over the vastness of time, this process has yielded the biological diversity we see today. Much has been learned about natural selection during the past two centuries, and indeed there are many complicating factors involved. However, the fundamental contribution of Darwin's *On the Origin of Species*[2] remains essential to evolution: heritable genetic variation and differential survival over the course of many generations can lead, eventually, to significant changes in biological

populations. This is the Darwin–Wallace theory of descent with modification, or natural selection.

Please note that this process explains *how* biological change occurs. It does so in the same way that you might explain *how* a steam engine works, or the process by which its action is caused: water heated to 100°C boils into steam, which rises and powers the rotation of a turbine, which then generates electricity at the local power plant, and spins the wheels of your nineteenth-century train, Mississippi riverboat, etc. As an analogy this is a bit dated, but the point should be clear: both explanations are about natural processes responsible for something we observe. It is equally valid to note that Thomas Savery designed the first steam engine, or that James Watt (among others) later improved it. However, the latter is an explanation of a different sort: it is one of agency, not cause. Riverboat passengers at some point may have expressed great admiration for Savery and Watt, the "creators" of their momentum. How does the engine work? Savery did it, helped by Watt. Such an interpretation is true in the sense that Savery and Watt deserve credit as the agency behind the steam engine. However, it says nothing about how the steam engine actually works. There is a materialist, or naturalistic, cause behind the function of their steam-propelled craft which is not changed by recognizing the agency of Savery and Watt in the development of its engine. This kind of natural causation is what I meant earlier when I referred to the "materialist orientation" of science.

The same distinction between agency and cause is very relevant to the current debate on evolution. Darwinian natural selection is a very specific set of ideas about the naturalistic basis by which animals across many generations may evolve. However, to quote the 1980s actor/comic Pee-Wee Hermann, there is a very "big but": exactly how the first organism appeared, or if a higher consciousness was somehow the agency behind biological replication, inheritance, and selection, is not part of the theory of evolution. Darwin himself made this clear in all six editions of the *Origin*. Consider the quotes Darwin listed on the reverse of his title page. In the first edition he cited William Whewell and Francis Bacon; starting with the second, he added another, from Joseph Butler:

> The only distinct meaning of the word "natural" is *stated*, *fixed*, or *settled*; since what is natural as much requires and presupposes an intelligent agent to render it so, i.e. to effect it continually or at stated times, as what is supernatural or miraculous does to effect it for once [italics in the original].

This quote is very important. It recognizes that the human distinction between "miraculous" and "natural" is a relative one, one which seems obvious to us only because we do not fully understand certain things—such

as the generation of life—which happen constantly and all around us. As early as 1860, as the second edition of the *Origin* was hot off the press, one of Darwin's regular American correspondents, the botanist Asa Gray, did not fail to observe this addition: "We notice with pleasure the insertion [into the second edition] of an additional motto on the reverse of the title page, directly claiming the theistic view which we have vindicated for the doctrine."[3] Gray's "theistic view" is the idea that natural selection is the means (or cause) by which God (the agent) has effected evolution. Darwin repeated this sentiment in the second through sixth editions:

> I see no good reason why the views given in this volume should shock the religious feelings of anyone. ... A celebrated author and divine [meaning another of Darwin's correspondents, Rev. Charles Kingsley] has written to me that "he has gradually learnt to see that it is just as noble a conception of the Deity to believe that He created a few original forms capable of self-development into other and needful forms, as to believe that He required a fresh act of creation to supply the voids caused by the action of His laws."[4]

Whether or not Darwin himself actually believed in supernatural agency is irrelevant to this point. Furthermore, it doesn't matter at all if you personally believe that there is a God-like agency behind biological diversity. The point is that Darwin's mechanism does not concern the subject of who did it, or why, and that Darwin recognized that his mechanism could not rule out a creator.[5] Rather, however life may have first appeared, he outlined a mechanism that humans can observe and understand. Once started, it allowed life to unfold into the diversity we see today. Whatever his personal beliefs may have been, based on his writings in the *Origin*, Darwin was a "theistic" evolutionist, i.e., one who permitted a divine agency behind the mechanism of biological evolution.[6]

To be sure, his process differs from a naïve interpretation of religious creation stories because natural selection is not a process of a human-like "god" tinkering with organisms as if they were organic Barbie dolls with lots of different outfits, each requiring manual (un)buttoning. But agency is most certainly not ruled out. Whatever the origins of his mechanism, Darwin identified a cause by which species evolve.

Philosophers and theologians have known for ages that scientific and theological explanations of the natural world do not have to be fundamentally at odds with one another. Based in part on the writings of St. Thomas Aquinas in the thirteenth century,[7] and Aristotle centuries before, the Roman Catholic Church has long recognized the distinction between two levels of causation—primary and secondary—which have parallels to what I've called agency and cause.[8] Augustine of Hippo (AD 354–430), a north

African citizen of Rome, is another major historical figure in Christian theology. He famously exhorted his fellow Christians not to force literal belief in the creation story of Genesis at the expense of rational thought.[9] The Catholic Church has followed in this tradition and (beginning with Pope Pius XII in 1950) has recognized that evolution is not fundamentally at odds with Christian faith. Its positive view on the compatibility of evolution and Christianity was made more explicit by John Paul II in 1996, again by Cardinal Ratzinger (now Pope Benedict) in 2004, and most recently in a March 2009 conference at the Vatican.[10] These statements have their roots in the works of philosophers and Christian theologians who lived centuries ago.[11] For example, consider chapters 69 and 70 from *Summa Contra Gentiles*, written around 1260 by Thomas Aquinas:

> [Some] men have taken the opportunity to fall into error, thinking that no creature has an active role in the production of natural effects. So, for instance, fire does not give heat, but God causes heat in the presence of fire, and they said like things about all other natural effects. (book 3, chapter 69)
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> It seems difficult for some people to understand how natural effects are attributed to God and to a natural agent. … So, if the action whereby a natural effect is produced proceeds from a natural body, it does not proceed from God. … However, these points present no difficulty … In every agent, in fact, there are two things to consider: namely, the thing itself that acts, and the power by which it acts. … [The] power of a lower agent depends on the power of the superior agent, according as the superior agent gives this power to the lower agent whereby it may act … as the artisan applies an instrument to its proper effect, though he neither gives the form whereby the instrument works, nor preserves it, but simply gives it motion. So, it is necessary for the action of a lower agent to result not only from the agent by its own power, but also from the power of all higher agents; it acts, [therefore], through the power of all. (book 3, chapter 70)

Creationists and some atheistic biologists have not carefully read Aquinas. They conflate agency and cause by thinking that our understanding of evolution's cause excludes an agency behind it. In fact, as a way of explaining things, agency and cause do not necessarily exclude or compete with one another.[12] To argue that they do in the case of evolution would be just as ridiculous as saying that steam-powered rotation of a turbine cannot be the mechanism behind riverboat thrust, because I know Savery and Watt did it, or to say that since a steam-powered turbine is involved, these Savery and Watt people are only a myth. It is possible to be completely oblivious to the agency (or cause) behind the steam engine, yet know quite well how it works (or who developed it). As I've just observed, ancient theologians, Darwin, and many subsequent authors have recognized this distinction.

Others have not, including many participants in the creation versus evolution debate. Consider this fairly typical passage from a 1999 book on theism and evolution:

> Before Darwin, theists could point to natural objects like the eye and then challenge their philosophically inclined critics to provide a better explanation than theism. Darwin provided a purely naturalistic account for apparent design in the natural world. … In the *Origin of Species* he challenges his critics, "It is so easy to hide our ignorance under such expressions as the 'plan of creation' or 'unity of design,' etc., and to think that we give an explanation when we only restate a fact." Darwin would have none of that kind of "sloppy thinking." Instead, he proposed a mechanism—natural selection—that would do the work of providing for the patterns in nature that others had only passively described. The results of the debate over design in nature for theism were very great. In the words of … Richard Dawkins, "Darwin made it possible to be an intellectually fulfilled atheist." … God is, at best, unemployed in the new cosmology.[13]

Despite citing the *Origin* where Darwin explains how "design" does not provide a cause for biodiversity but only asserts an agency behind it, these authors imply (noting Richard Dawkins' agreement) that natural selection has replaced theism, leaving God "unemployed." But this does not follow: neither atheists nor fundamentalists know the extent to which God as an agent is "employed" or otherwise occupied with a mechanism such as natural selection. Their assertion that he is not is similar to denying the agency of Thomas Savery due to the cause of steam driving a turbine, or, to draw on Aquinas' example, that an artisan is not responsible for nails in a table because it was the hammer that delivered the force. Unfortunately, other examples in which authors have conflated agency and cause are not hard to find.

## THE MOST GIFTED BIOLOGY WRITER OF OUR TIME

Stephen Jay Gould died on May 20, 2002. I am one of many biologists who, by reading his engaging prose in books such as *Ontogeny and Phylogeny*, *Mismeasure of Man*, and *Wonderful Life*, was drawn into this field in which he played such a major role.

I found Gould's review[14] of Phillip Johnson's book, *Darwin on Trial*,[15] very entertaining, much in the same way that spectators gawk at blood spilled at a prize fight. Gould had no patience for the misrepresentations and half-truths that filled Johnson's book, and was downright mean in his portrayal of the author himself. Johnson sought to paint evolution as a "theory in crisis," repeating claims of alleged scientific and moral inadequacy that have been

rebutted over and over again since 1859. Gould saw through this verbiage and critiqued Johnson's book as a misinformed, quasi-political document, dependent on the reader's ignorance of biology and the history of science to have any effect. Like the Roman public who witnessed Christians thrown before a hungry lion, I enjoyed Gould's shredding of Johnson's book. This lion's name was Steve Gould, and I was cheering him on.

Creationists and atheists alike may read this and come away with the conclusion that by sharing Gould's disdain for Johnson's book, I am an atheist, hostile to religion itself. Such a portrayal attracts some level of blood-lust, identifying me as one of "us" or "them" depending on your orientation as a reader. However, if our goal here is to understand why two academics are shouting at each other, this reaction is not really productive. The disagreement between Gould and Johnson, as evident in Gould's[16] review of *Darwin on Trial* and in Johnson's reply to this critique,[17] is one minor footnote in a long and rancorous debate on the boundaries between science and religion in Western society.

To make clear my reaction to this debate as a religious paleontologist, I'd like to briefly restate its content. The author of *Darwin on Trial*, Phillip E. Johnson, is widely regarded as a founding member of what is now called "intelligent design" (or ID). This idea is derived from some of the same protagonists who had previously advocated creationism,[18] connected in one form or another to the religious, anti-evolutionist movement whose public form has tracked decisions made by the US Supreme Court in 1968 and 1987.[19]

Despite its religious roots, ID asks questions of "design" in nature without an overt appeal to Christianity or other major religions. Descriptions of ID, for example in publications by Michael Behe,[20] state that ID proposes to search for evidence that life was designed, much in the same way that the Search for Extraterrestrial Intelligence (SETI) program searches for signs of extraterrestrial life. SETI researchers sift through vast quantities of cosmic radio transmissions, searching for a pattern that might identify an intelligent source. It is assumed that natural, non-intelligent sources of radio waves, such as a pulsar, would lack patterns, like the series of prime numbers that Jodie Foster, in her role as a data-hungry scientist, dramatically deciphered in the 1997 movie *Contact*. The SETI researcher played by Jodie Foster was not looking for anything supernatural; most ID advocates claim they're not either.

We'll discuss the extent to which ID is about a supernatural intelligence in Chapter 2. For now, it's worth noting that scientists would deny from the outset that a supernatural force could figure at all in their list of possible explanations for something biological. Given the fact that evolutionary biologists are looking to explain the mechanisms behind biodiversity, *how* it

has come to exist, this is a legitimate restriction. This is not to say that reasonable scientists object to discussion of agency or purpose in biology, only that doing so is peripheral to understanding the mechanisms of evolution. Nor does it mean that a natural agency is beyond the scope of evolutionary science; paleontologists consider the products of natural agents all the time (e.g., animal trackways, bite marks of predators, or stone tools). However, this restriction does mean that theories proposing to explain natural phenomena should be grounded in the natural realm; any theory about nature should be subject to testing based on the collection of data from nature.

Of course, it's possible that some kind of extraterrestrial being, perhaps supernatural, seeded the Earth with life and its complex accouterments. Because this possibility exists, say advocates of ID, it should be a legitimate target of scientific investigation. They propose to do this by searching for patterns of complexity in the make-up of life—for example, among natural "machines" of varying scales from a protein-transport biomolecule to the *Tyrannosaurus rex* locomotor apparatus. Their search is for units of "irreducible complexity" among these machines, units that could not have been assembled by the randomness they attribute to Darwinian natural selection, just as a pulsar would probably not emit a series of radio signals in units of prime numbers (i.e., 3, 5, 7, 11, 13, 17, etc.).

Setting aside for a moment the fact that the randomness of galactic radio waves is not at all comparable to the essentially *non*-random process of natural selection,[21] this kind of search for agency in nature is what I mean when I say "intelligent design." Taken at face value from its proponents, ID is not specifically about the Judeo-Christian story of Creation. ID is about the search for human-like "intelligence" in the origins of biological diversity. What IDers do not emphasize is the distinction between agency and cause, and the fact that their endeavor is entirely concerned with the former.

Some in the Darwinist camp have also neglected the importance of distinguishing between agency and cause. Returning to Gould's critique of Johnson's *Darwin on Trial*, in that review he contradicts some of his own statements made elsewhere in which he advocates the incompatibility of Darwinism and religion. For example, in a 1977 collection of his essays, Gould famously stated that "Darwin … was vindicated in his cardinal contention: Cambrian life did arise from organic antecedents, not from the hand of God."[22] A similar quote was part of a February 1982 article in *Discover* magazine (although in fairness its parenthetical allows for a sort of divine beginning): "No intervening spirit watches lovingly over the affairs of nature (though Newton's clock-winding god might have set up the machinery at the beginning of time and then let it run). No vital forces propel evolutionary change. And whatever we think of God, his existence is not manifest in the products of nature."[23]