Evolution, Science, and Religion
Making Your Way through the Tangled Bank

By Louise S. Mead
BEACON Center for the Study of Evolution in Action

Preface
As an evolutionary biologist and science educator who was also brought up participating in Catholic faith traditions, I’ve always been interested in exploring the ways people seek to integrate the domains of science and religion/spirituality. For me, when I first learned about Darwin’s ideas about evolution in ninth-grade biology, it was as though the natural world, and even human nature, finally made sense. A course with Dr. Lynn Margulis on environmental evolution altered my entire relationship with science, allowing me to see the dynamic and tentative nature of scientific information. A new awareness of how science worked led me to pursue research, and a PhD in evolutionary biology, with Drs. Stephen Tilley and Laura Katz, studying the patterns and processes of speciation in a group of salamanders.

Yet experiences over the years led me to continue exploring spiritual questions and attempting to connect these questions and experiences with my understanding of the biological world. As a graduate student in evolutionary biology, I noticed books about intelligent design and irreducible complexity in the science section of bookstores. I was initially intrigued by the writings of Jeremy Narby in The Cosmic Serpent, where he explored the idea that the knowledge shamans obtain through ayahuasca-induced journeys is gained from the plants themselves.

Over time, however, I realized these attempts to integrate supernatural explanations with science were unsatisfactory. Most of these ideas, when brought before a scientific framework of evidence-based reasoning, fell apart. Hence, the more I looked for connection, the more I realized the importance of keeping these realms separate. Religious/spiritual journeys are, by their very nature, personal and subjective. And while I have a personal scientific journey as well, scientific information is public, accumulates through a very specific process, is testable, and, perhaps most importantly, seeks to provide natural explanations for natural phenomena. I’d argue that any attempt to devise supernatural explanations for natural phenomena, or suggest science can validate or invalidate religious beliefs in general, diminishes both science and religion. Yet it is clear from polls about acceptance of evolution that many people need to find a way to accommodate these two ways of understanding.
In the following pages, I explore how people’s worldview influences both their understanding and acceptance of evolution. Hopefully, this exploration will provide an opportunity to engage in dialogue about the nature and process of science and how it is and/or is not compatible with religion.

**Learning Objectives**

• Identify the nature of knowledge in science.
• Use evidence to defend the following statement: Evolution is both fact and theory.
• Describe how your personal religious or spiritual belief system intersects with the science of evolutionary biology.
• Explain the term *creationism*.

**Evolution**—that single word describes how all life on the planet diversified “from so simple a beginning” (Darwin 1859) into “endless forms” over the past 3.5 billion years. Yet for some people, the intricate and complex nature of life can seem implausible without a supernatural account. Some envision a god or gods guiding natural processes, or creating all living organisms and allowing natural processes to develop from there. Others have a religious worldview that requires them to completely reject scientific evidence in favor of adhering to accounts laid out in religious texts or by elders in their community.

Many students may wonder why they are being asked to address a social/cultural/religious topic in an evolutionary biology course. Other students are wondering how anyone cannot believe that a divine entity or entities created the world we see today. People exhibit variation in their belief systems, and these beliefs can, and do, affect their worldview and how they interpret scientific information. These beliefs can create particular challenges for learning about evolution. Evolutionary biologists explore questions related to the origin and diversification of life—everything from cellular interactions to the growth and development of physical structures to the interactions between individuals and their environment to the evolutionary changes observed in populations over time. The very nature of these questions and explanations can be considered in conflict with ultimate accounts of these same phenomena as viewed by some religions.

On a superficial level, evolution refers to the fact that the relative frequencies of inherited traits in populations change over generations. Familiar and classic examples include (1) increases over time in the numbers and types of bacteria resistant to our antibiotics (Livermore 2009); (2) changes in the frequency of dark- and light-colored peppered moths (*Biston betularia*) in populations occurring in English cities during the late 1800s and early 1900s (Edelsten 1864); and (3) changes in the average beak morphology of ground finches on Daphne Major in the Galápagos Islands (Grant et al. 1976). Today modern evolutionary biologists seek to elucidate, at all levels, how these changes originate, how they persist, and eventually how the basic components of mutation, variation, natural selection, and genetic drift can explain phenomena like the evolution of cooperation and complex traits. For each of the classic examples just listed, science, as an endeavor, has continued to advance our knowledge and further illuminate the biological mechanisms (e.g., molecular, developmental, and selective) involved in evolutionary change ([Box 1](#)).

**What does evolution mean to you?** Stop for a moment and reflect on this question. Record your thoughts in the margins of the book. Now do a Google Image search on the word *evolution*.

The top image that comes up, and probably the most common misconception, is that evolution is the linear progression from monkey to human ([Figure 1](#)).
The process of science continues to inform our understanding of classic evolutionary examples in the following ways:

1. **Exploration and discovery.** The inevitability of evolution means scientists must continue to discover new methods to counter the evolution of antibiotic resistance. Over time, bacteria evolve resistance, and these antibiotic-resistant bacteria are becoming increasingly common, causing a global health crisis. Recent advances in our understanding of the mechanisms by which bacteria are resistant or acquire resistance are important developments in our continued attempts to identify new antibiotics (Blair et al. 2015). Scientists are using new approaches to culture bacteria in hopes of identifying new antibiotics (Ling et al. 2015) and testing different approaches to treatments that may ultimately constrain the evolution of resistance (Kim et al. 2014). Hospitals are employing new genomic approaches to identify specific infectious bacteria and provide the most appropriate treatments (Leopold et al. 2014). These recent advances are important in our continued attempts to better respond to the inevitability of evolutionary change.

2. **Community analysis and feedback.** The evolution of melanism in the peppered moth in response to industrial pollution is included in many high school and college biology textbooks because it is such a great example of evolution in action. Unfortunately, it has also come under attack by creationists and scientists because the original experiments were not biologically relevant. The very process of science, however, has ultimately reinstated the peppered moth as an excellent example (Majerus 2009). Following criticism of the original experimental procedures, Cook et al. (2012) published revised experimental protocols followed by Majerus that showed evolutionary change in the moths’ color through natural selection induced by predation. The scientific process allowed for critique and revised experimentation, and ultimately verification of the peppered moth as an example of evolution in action.

3. **Testing ideas.** The Grants’ pioneering work on Galápagos (or Darwin’s) finches provided support for the hypothesis of an adaptive radiation in the 14 closely related species. The primary diversity among these species lies in the size and shape of their beaks, and the Grants showed how small differences in the three major dimensions—depth, width, and length—of the beak can have major consequences for the overall fitness of the birds. If evolutionarily relevant, these phenotypic differences should be controlled at the gene level. Recent research has shown that calmodulin (CaM) is expressed at lower levels in the robust beaks of ground finches than it is in the long and pointed beaks of the cactus finch (Abzhanov et al. 2006). More recent research found an additional three candidate genes involved in regulated morphogenesis of the premaxillary bone, which forms later in development and becomes the most prominent functional and structural component of the adult upper beak/jaw (Mallarino et al. 2011). These results suggest how the tightly coupled width and depth components can evolve independently through the modification of different developmental pathways, creating the morphological variation on which selection operates and ultimately contributing to the observed adaptive radiation.

---

**Science in Action**

**Figure 1** Example of the linear representation for the evolution of humans. Note that these series typically culminate, problematically, with a white male. (Art by Carl Buell. Used with permission.)
There are numerous variations on this general theme, including one for Homer Simpson, but none of them accurately depict what Charles Darwin envisioned—a branching tree (Figure 2) depicting the process of descent with modification from a common ancestor. The idea of a linear progression dates back to antiquity’s Great Chain of Being or Scala Naturae (literally, “a stairway of nature”), which viewed everything in the universe as occupying a specific “place” in a divinely planned hierarchy (see Archibald 2014 for additional discussion of using visual metaphors to describe biological order). In this linear view, humans are seen as being above all other animals and plants. Such a linear and progressive view of evolution is incorrect.

**Now try a Google Image search for biological evolution.**

The marching hominids are still among the results, but now the images include branching trees, depicting the process of descent with modification, often emphasizing deep time. These two different search results exemplify how many people continue to view evolution as a linear and progressive process, whereas evolutionary biologists rely on these visual representations to emphasize the importance of common ancestry and the branching process of speciation.

Complete knowledge of evolution requires an understanding of how mutation, inheritance, selection, genetic drift, and migration cause the frequency of traits in populations to change over time, giving rise to new species, as well as an understanding that what links current species is a long history of shared ancestry. Accurately and adequately depicting evolutionary change in the original monkey–human diagram requires adding branches that connect the representative species, and characters that differentiate each of the lineages (Figure 3). Evolutionary biologists would also be interested in what processes were involved in the appearance of these new traits, and how these traits developed at a molecular and cellular level. They might also ask what causes new lineages to split off and eventually become isolated from ancestral lineages—which might include a role for sexual selection, reproductive isolation, and environmental variation. Discovering which lineages went extinct, and when and why, can also lead to additional questions and hypotheses. Evolution provides the framework for investigating many of these questions.

**Take another moment to complete “My current understanding of evolution is...” by explaining what you think evolution is and how it works.**

People integrate new knowledge into their current understanding over time, often holding both naïve and scientific explanations simultaneously (Nehm and Ridgway 2011). Hence, in preparing this supplement, the author asked 588 college students from 25 colleges and universities across the country, all taking a course on evolution, to respond to a series of questions about their understanding of evolution. Questions included whether and, if so, how their personal beliefs influenced (1) their ability to learn about evolution and (2) their acceptance of evolution. Participants also were asked to suggest anything that could occur in or out of class that would make learning about evolution more compatible with their belief system. The survey responses provided guidance for the supplement, and created an opportunity to share the views of other undergraduates with those currently taking similar courses.

A word cloud (Figure 4) created from the responses suggests that these students understood evolution to include “biological change” over “time”; many referred to “alleles,” “species,” and “[natural] selection.” Rarely, however, was common ancestry included. The underrepresentation of common ancestry is not surprising, but certainly significant. Descent from common ancestors, with modification by means of natural selection, was exactly the thesis Darwin was arguing for in *On the Origin of Species* (1859).
Millions of years ago

Adaptations for walking bipedally, smaller canine teeth
Feet partially adapted for bipedalism
Enlarged cheek teeth and jaws

Massive cheek teeth and jaws, enlarged chewing muscles

Slightly larger brain (600 cc), more vertical face without a snout, fingers capable of precision grip, ability to make simple stone tools for processing food including meat
Smaller jaws and cheek teeth, long legs and arched feet well suited for long-distance walking and running, larger brain (Homo erectus brains range from 650 cc to 1200 cc)
Sophisticated stone flakes, tools for hunting, brain size increases to 1200 cc
Large brain (1400 cc), small face tucked below braincase, rounded cranial vault, small browridges, capacity for art, symbolic thought, full-blown language

Figure 3 A complete depiction of human evolution includes branches suggesting common ancestry, as seen in this evogram from the second edition of Zimmer and Emlen.
Now consider how your definition of evolution fits with the discussions above, and how your religious beliefs influence how you view this information.

How would you respond to each of the following paired statements?

<table>
<thead>
<tr>
<th>Paired Statements: Agree with one of the two.</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>· All plants and animals were created in their present form.</td>
<td>☐</td>
</tr>
<tr>
<td>· Species of plants and animals alive today evolved from earlier forms.</td>
<td>☐</td>
</tr>
<tr>
<td>· Human beings have existed in their present form since the beginning of time.</td>
<td>☐</td>
</tr>
<tr>
<td>· Human beings have evolved, in response to environmental changes, over long periods of time, from earlier forms of life.</td>
<td>☐</td>
</tr>
</tbody>
</table>

How students responded to these statements was connected to their success of integrating their religious beliefs with the evidence for evolution. Of the 588 students completing the questions, 95 percent agreed that “species of plants and animals evolved from earlier forms” (Figure 5). Slightly fewer (88 percent) agreed that humans evolved from earlier species. Five percent of students rejected evolution when discussing animals and plants, but that response increased to 12 percent when students were asked the same question about humans. These results suggest that some students view humans as separate or different from other animals and therefore have more difficulty accepting human evolution.

Students also exhibited different ways of viewing the intersection of their religious beliefs and the evidence for evolution. Some students indicated their belief in God did not affect their acceptance or learning of evolution, often citing ways of accommodating evolution within their worldview. A few students suggested their religious views were in conflict with evolution, often citing problems with evidence for the origins of life or the lack of proof for evolutionary change as nonreligious reasons to discount evolution. Some of these students may see a difference between saying, “I reject evolution because it conflicts with the Bible” and saying, “I reject evolution
because there is no good evidence for it.” My hypothesis is that the former influences the latter.

The responses also indicated some students have varying degrees of understanding about what evolution is. For example, some stated that evolution is directional (as seen in Figure 1) rather than branching, or that evolution is the same as natural selection, rather than natural selection being one mechanism of evolutionary change. These commonly held misconceptions often stem from naïve ideas about the essential nature of organisms, especially when they are uncorrected or reinforced in formal biology education. Being clear about how these ideas influence your own current understanding of evolution can affect how you interpret the evidence for evolution. For example, thinking of evolution as a linear progression can create an expectation that evidence for evolution should include all missing links between living species.

The Nature of Science

As a graduate student, I spent an afternoon hiking a small portion of the Appalachian Trail in search of a new locality for a particular species of salamander. The locality was important as it represented a contact zone between two forms, and I was trying to understand more about what factors might be contributing to the genetic patterns we were observing in the frequency of traits across the contact zone. There appeared to be a sharp boundary, but there was no obvious geographic explanation for what might be preventing gene flow. One hypothesis included that other factors were involved, such as differences in courtship behavior that resulted in differential mating and reproduction.

But this particular afternoon I ran into an older gentleman—a local who, when I explained I was looking for salamanders, replied, “Oh, you mean spring lizards” (a general term for any salamander that lives in creeks in the southern Appalachians).

Later that day, I ran into this gentleman again. I’d hiked all day and not found any animals, so he suggested we travel down the road a bit to his mother’s property where he’d caught salamanders as a child. As we were flipping over rocks and logs, and I showed him the species I was in search of, he exclaimed, “Oh, you meant rock lizards, not spring lizards.” He knew right away that the slightly more terrestrial version I sought was different from the ones that lived closer to the stream. He did not know the scientific names for these animals, but he could tell they were different.

I share this story because it is a great example of different ways of knowing about the world. I’d relied on my scientific training to identify these salamanders, whereas this gentleman relied on personal experience.

When we talk about different “ways of understanding,” what do we mean? Science, Evolution, and Creationism (2008), published by the National Academy of Sciences and Institute of Medicine states, “Science and religion are based on different aspects of human experience” (p. 12). So what are these aspects of human experiences, and if both are intrinsically human, how can we be sure that one depicts the natural world more accurately than the other? What is the nature of scientific explanation, and how does this compare with religious accounts?

In science, explanations deal with natural phenomena—and, perhaps most importantly, they are dependent on empirical evidence, information acquired through quantifiable and repeatable observation and experimentation. But if scientists relied

Figure 5

Percentages of college and university students taking a course in evolution who agreed with statements about the evolution of plants, animals, and humans.
only on evidence that they personally accumulated, they wouldn’t get very far. Science is therefore also a social endeavor. Scientists rely on one another’s evidence, making it public so that other scientists can use it. But they don’t rely on it uncritically, because they recognize that every scientist is fallible (and therefore knowledge is tentative). It must be possible at least in principle to check putative explanations (showing that experiments and data can be replicated) against the evidence and then accept, modify, or abandon explanations as indicated.

Religious faith, on the other hand, does not depend on empirical evidence. Claims to religious knowledge are not necessarily modified in the face of conflicting evidence, and ultimate explanations generally rely on supernatural forces or entities (National Academy of Sciences 2008). As a result, religious accounts are not scientific explanations. Take, for example, the “mystery of mysteries,” the origin of species. Historically, religious teachings provided a solution to the mystery, but this account—divine creation—was not a scientific solution to the problem. It included no explicit mechanism that could be observed, studied, or tested.

Darwin sought an explanation for the origin of species that was based on natural phenomena. He was not alone in his quest for such a natural explanation. Many people before Darwin pondered this question, and both Darwin and Alfred Russel Wallace identified a possible mechanism. Importantly, their proposed mechanism for evolution, natural selection, was an observable and generalizable process. They made explicit hypotheses that could be tested and, if their predictions turned out to be incorrect, could be rejected. Again, neither Darwin nor Wallace’s ideas of descent with modification by means of natural selection would have been accepted had they not been tested against observations and experimental evidence from the natural world.

Knowledge in science is the result of a process in which ideas proposed to explain a phenomenon in the natural world are then tested against observations, experiment, and existing knowledge. Depending on the outcome, the ideas are accepted, modified, or rejected. Knowledge accumulates through this process. But it is always provisional, subject at least in principle to further revision in the light of new data or theory. Despite reckless claims by the media, and at times by scientists, science does not, and cannot, prove any idea definitively.

The tentative and provisional nature of information generated through the scientific approach, however, does not minimize the significance of its results or the conclusions drawn from the data. Yes, the idea that Earth is round is in principle revisable, but that doesn’t mean there is any realistic prospect of scientists revising or abandoning the idea. It does, however, highlight the importance of being aware of the methods and techniques used in generating hypotheses, collecting and analyzing data. Scientific testing is a process in which only those hypotheses that can adequately account for the data remain (Pennock 2004). Hypotheses that do not adequately explain the data are rejected. New data can be used to test an old hypothesis and may result in either rejection of the hypothesis or generation of a new hypothesis.

Evolution as Fact and Theory

I have long admired the work of Peter and Rosemary Grant, evolutionary biologists at Princeton University. They began traveling to the Galápagos Islands every year to collect data on a population of Darwin’s finches—the medium ground finch, Geospiza fortis, living on Daphne Major. The Grants have been able to survey every medium ground finch on the island, collecting data on body mass, beak width, and family relationships—who mated with whom, and how many offspring each individual had in a given year. Based on these data, collected over many generations, the Grants have watched how specific traits can directly affect the ability of individuals to survive and produce offspring that survive to reproductive age. They have seen that this differential survival and reproduction determines the distribution of that
particular trait in the next generation (see the second edition of Zimmer and Emlen, Chapter 8, for additional details). By following traits across generations and observing changes that are the result of selection, the Grants’ work shows us that evolution is fact—change happens—as well as theory, corresponding to Darwin’s thesis that change is caused by natural selection. These are the two elements of evolution that I now realize were so powerful for me as a high school student taking biology—they made my own observations of variation and diversity in nature finally make sense.

In science, what do the words **fact** and **theory** mean? Take a moment to define these terms for yourself. Now check out how the National Academies of Science, Engineering, and Medicine define these terms: http://www.nas.edu/evolution/TheoryOrFact.html.

What do we mean when we say evolution is both a fact and a theory? When scientists claim that evolution is fact, they are referring to the historical reality that species are related through common ancestry, and they are saying of this scientific explanation that it has been tested and confirmed so many times that there is no compelling reason to keep testing it. There is no question that the distribution of heritable traits in populations change over time. In fact, we can often observe evolution happening in real time—literally before our eyes—by tracking populations as alleles increase or decrease in frequency from one generation to the next. Current and relevant examples include month-by-month evolution of the influenza virus and the evolution of resistance to antibiotics in bacteria. Evolution as fact is supported by a massive amount of evidence from a wide array of independent sources (Gregory 2008), many of which are further detailed throughout Zimmer and Emlen. (See, for example, the discussion of fossil and molecular evidence for the evolution of tetrapods on pages 108–114, 277, and 279 of the second edition.)

Evolution is also a theory. The general public often uses the term theory to refer to a hunch or a guess. In science, however, a theory is simply a comprehensive explanation of some aspect of nature. The theory of evolution thus refers to the proposed explanations for how descent with modification occurs—through natural selection, mutation, genetic drift, and the like. Since theories are explanations, they can be used to make predictions about natural events or phenomena that have not yet been observed. Evolutionary theory is used to make predictions about the existence of extinct organisms with characters that were important for evolutionary transitions (e.g., the discovery of *Tiktaalik*). Similarly, scientists are examining the genomes of species alive today to infer important changes associated with evolutionary transitions (Amemiya et al. 2013) and with sequencing DNA from fossils to examine predictions about human history (Sankararaman et al. 2014).

Why is the dual nature of evolution as fact and theory important? Primarily because of the common misconception that evolution is “not a fact but just a theory.” This statement reflects a misconception about both key terms. First, as noted earlier, the general public often uses theory to mean a hunch or a guess, whereas in science a theory is a comprehensive explanation. To acknowledge that the theory of evolution is a theory is not to admit that it is conjectural or speculative. Instead, it is a statement that the theory of evolution seeks to explain a broad range of phenomena—something that it does very well. Second, while the general public tends to view facts as constant and never-changing, scientists do not view facts as “absolute certainty” (Gould 1981). In science, fact typically refers to an observation, measurement, or other form of evidence that can be expected to occur the same way under similar circumstances (National Academy of Sciences 2008). Facts may be accepted as true, but this acceptance is provisional, in the sense that they may be replaced by newer or better information. For example, the results of an experiment may be interpreted as facts, but later examination may reveal that the results were confounded by another variable not considered originally or by a better experiment devised to include a larger or more appropriate sample size (National Academy of Sciences 2008). So to
claim that evolution is a fact is not to insist that it is certain and absolute. But it is to
claim—correctly—that there is overwhelming evidence for it.

Belief Systems and Science

I often have discussions with students whose views on science and religion
can be complicated, but often informative. For example, one student told
me that he neither accepted that humans have existed in their present form
since the beginning of time nor believed that humans evolved from other life-
forms. The student expressed interest in learning new information, but added
that when learning about evolution, he finds it problematic when instructors
and classmates take a dismissive approach to religious and personal beliefs
or assume that religion is equivalent to the dominant form of Christian cre-
ationism (involving a 6000-year-old Earth). Another student, in attempting to
explain how genetic changes occur in a population over generations, asked if
this was evolution, but commented that didn’t match what she had learned
before—that evolution was humans coming from chimps. As an educator I
want to encourage curiosity and an open mind in the students I interact with.
For a few students, this clearly requires exploring their current understand-
ing of evolution and, at times, religion. For me, it requires respecting their
personal religious beliefs, even if I don’t share or understand their perspec-
tive, while ensuring the scientific explanation is not compromised in my
efforts to be respectful. For me, this is where science and religion intersect, in
the realm of education.

If science and religion represent two different ways of understanding our world, it is
certainly possible for these views to conflict with one another. If so, the prospect of
a zero-sum competition for cultural authority looms: either science defines what is
true and religion must follow, or religion sets forth the truth and science must adhere.
Each of these views certainly has its proponents.

There are, however, additional models for how people relate science and religion.
Ian Barbour, a professor of physics and religion at Carleton College, proposed four dif-
f erent models for the interaction between religion and science: (1) conflict—as noted
above; (2) independence—science seeks answers to causal events, whereas religion
asks about the meaning and purpose of our lives; (3) dialogue—acknowledges simi-
larities in methods as well as limits of knowledge; and (4) integration—allows for
elements of a designer in natural explanations (Barbour 2000).

To begin a dialogue about the relationship between science and religion, knowl-
edge of some of the different world religions and spiritual traditions can help create
a broader context for respectful discussions. The largest world religions include Bud-
thism, Chinese traditional religion, Christianity, Hinduism, and Islam.

• Although a few different Buddhist traditions do worship supernatural entities,
most Buddhists generally do not worship any gods or God. They seek to attain
spiritual enlightenment by letting go of yearnings toward sensuous desires and
attachment to the self; however, they do see the truth found by the Buddha to be
final and absolute.

• Chinese traditional religion is practiced by the Han, who primarily worship shen.
This concept broadly translates into spirits and other expressions of energy.

• Christians believe that God is the creator and sustainer of the universe and that
Jesus is the Son of God and the savior of humanity.

• Hindus exhibit a range of viewpoints that can include both monotheistic and
polytheistic strands, but generally they worship one Being of ultimate oneness
(Brahman) through infinite representations of gods and goddesses and attribute
creation, preservation, and destruction of the universe to these entities.
• Muslims believe there is one almighty God, Allah, the creator of the universe. Muhammad is the last prophet, and his words and lifestyle are to be followed.

Even within a single religion, there are further distinctions or denominations. For example, Christianity includes Catholicism, Eastern Orthodoxy, Protestantism (which includes Baptists, Evangelicals, Lutherans, and Methodists), and various Restorationist groups (which include Jehovah’s Witnesses, Pentacostalists, and Seventh-day Adventists). All these groups can have different views that then influence interpretations of the relationship between science and religion.

**How do you define or identify your personal religious beliefs? Take some time now to examine your own religious beliefs, and consider if these beliefs influence how you interpret natural phenomena.**

**Religious voices for evolution.** Three of the four models proposed by Barbour include components that lessen the potential conflict between science and religion, and these models appear to resonate with many people. When asked what might help address potential conflict between religion and evolution, students surveyed for this chapter indicated that additional discussion of religious viewpoints would be helpful (dialogue). Polls also suggest (Newport 2014) that 30 to 40 percent of the public is willing to accept that humans and other organisms evolved from earlier species, if also allowed to stipulate that the process was somehow guided by God (integration), and many religious leaders promote accommodation of these two worldviews. In an address made on October 27, 2014, for example, Pope Francis stated, “Evolution in nature is not opposed to the notion of Creation, because evolution presupposes the creation of beings that evolve.”

Religious organizations have also made statements in support of compatibility between evolution and religious faith. *Voices for Evolution* (Sager 2008), a publication of the National Center for Science Education, provides a collection of statements in support of evolution from 26 religious organizations (http://ncse.com/files/pub/evolution/Voices_3e.pdf) that include the American Jewish Congress, the General Convention of the Episcopal Church, the Lutheran World Federation, Unitarian Universalist Association, the United Methodist Church, and the United Presbyterian Church of the USA. The Clergy Letter Project and Evolution Sunday, started by Michael Zimmerman, is a nationwide project that encourages clergy and their congregations to engage in discussion and reflection on the relationship between religion and science. Through the Clergy Letter Project, over 13,000 religious leaders from various denominations have signed letters stating that the theory of evolution is a “foundational scientific truth” and that it does not conflict with their specific religious traditions.

**Scientists’ voices for the role of religious beliefs.** A number of scientists have also spoken out in support of a model of nonconflict between their personal religious beliefs and an acceptance of evolution, suggesting they fit Barbour’s independence model. Perhaps the two most prominent and outspoken are Kenneth R. Miller, a biologist at Brown University, coauthor of a widely used high school biology textbook, and author of *Finding Darwin’s God: A Scientist’s Search for Common Ground between God and Evolution*, and Francis Collins, director of the National Institutes of Health and author of the book *The Language of God: A Scientist Presents Evidence for Belief*.

Miller’s (1999) approach, as a self-identified Catholic, is to point out that accepting the scientific validity of evolution and professing belief in a supreme being does not have to dilute both if one doesn’t assume religion tells us about how life came about or assume science can tell us the meaning of life. Collins, an evangelical, approaches bringing these two worldviews together by suggesting harmony between faith and science can be found by believers curious to understand the “grandeur of His creation” and by scientists acknowledging the “timeless spiritual truths that faith presents” (2006).

Stephen Jay Gould (1997) provided an agnostic perspective, suggesting that science and religion be viewed as nonoverlapping magisteria (NOMA). *Magisterium*
refers to teaching authorities, and in this case, science informs us of the “empirical universe” whereas religion provides guidance over “moral meaning and value.” Science answers the why and how questions about the natural world; religion provides guidance regarding moral behavior.

There are many resources on the topic of science and religion (Box 2). As noted earlier, how any individual chooses to integrate these concepts is often very personal.

What are the positions on religion and evolution promoted by the religious denomination that you identify with? Research these views. Do you agree with these statements? Are there other ways of interpreting these positions?

What Is Creationism?

When students or colleagues tell me they are creationists, I am always curious to know what exactly they mean. To what beliefs, as promoted within creationism, do they adhere? Do they think God played some role in the creation of the universe? Do they believe all life on Earth was created 6000 to 10,000 years ago? Do they believe dinosaurs lived at the same time as humans? I am also curious to know where and how they came to these beliefs. Did they learn them in church? Do they belong to a religious group that actively promotes creationism and/or intelligent design? Have they been told there is scientific evidence for intelligent design? I am interested in these questions because saying you are a creationist can describe a very broad interpretation of the role of God in creating the Universe, whereas creationism, creation science, and intelligent design—even if promoted by individuals with advanced degrees in science—hold very specific assumptions that ultimately must reject any meaningful and truthful way of bringing science and religion together. If one’s religious views are truly compatible with science, they should be able to account for the overwhelming evidence that Earth is 4.5 billion years old, species change over time, and all species share common ancestors.

The conflict between evolution and creationism is not new to the twenty-first century. Long before Darwin published On the Origin of Species, people argued over the idea that species change over time. Many believed that every species had essential and unalterable characteristics. These ideas were developed largely from Aristotelian models, and they fit well with natural theology—the belief that evidence of God could be found in the natural world. An alternative view, extended from observations...
that physical laws could explain the physical world, sought to identify natural explanations for the patterns observed in the biological world. These ideas focused on the variation of species, and observations—of, for example, fossils and geological changes. Georges-Louis Leclerc, Comte de Buffon, suggested that living organisms did change over time in response to the environment. Charles Lyell suggested that the same types of natural processes that are happening today occurred in the past, that geological change is slow, and that Earth must be old. These ideas contradicted contemporary views for the origin and nature of species.

Today, creationism describes the rejection of scientific explanations of the known universe in favor of special creation by a supernatural entity (National Academy of Sciences 2008). Note that to reject creationism so defined is not to reject the idea that God created the world and everything in it; it is only to reject a specific set of ideas about the way that God created. Note also that creationism so defined is not necessarily tied to Christianity. Other religions promote replacing scientific explanations with their own supernatural accounts of natural phenomena. In the United States, creationism is typically promoted by small groups of politically active religious fundamentalists who believe that only a supernatural entity can account for the biological diversity of life on Earth.

The dominant form of creationism in the United States today is what’s called young-earth creationism, which holds that the universe, Earth, and all life observed today were created essentially in their present forms within the last few thousand years. In addition to young-earth creationists, there are old-earth creationists who accept the great age of the universe and Earth, but still reject evolution.

There are also those who promote the idea of intelligent design (ID), suggesting that life is too complex to have evolved, which provides evidence for a designer. Mindful of past creationist defeats, proponents of intelligent design do not identify their view as creationism, but their accounts still rely on some type of supernatural entity to explain biological phenomena. Intelligent design can also appear at first glance to allow for an integration of science and religion, by claiming there is scientific evidence for a designer. But the scientific community still rejects such a “God of the gaps” view—because it cannot be tested, it does not fit within methodological naturalism.

Examining the history of the societal controversy between creationism and evolution in the United States can help explain why there is still so much separation between the views of scientists (98–99 percent of whom accept evolution) and the general public. Eugenie Scott, former director of the National Center for Science Education, a nonprofit that defends the teaching of evolution in the public school classroom, provides an excellent review of this history in her book Evolution vs. Creationism (2009). To summarize: American creationism, as a movement that has affected the teaching of evolution in the K–12 school system, largely originated in the 1920s when a group of Christian Fundamentalists became concerned that children were being taught that the Bible was nonsense. The Butler Act, passed in Tennessee, banned the teaching of evolution. In response, the American Civil Liberties Union financed a case brought against John Scopes, who was accused of teaching evolution and violating the Butler Act. Scopes was found guilty and fined $100. The case was later dismissed, but various state laws continued to uphold the ban on teaching evolution. Eventually, however, scientific advancement, and a desire to prepare young people to be scientifically competitive, caught up with the educational system. A series of legal cases resulted in rulings that made clear that banning the teaching of evolution, teaching creationism or creation science, and teaching intelligent design all violated the Establishment Clause of the First Amendment (Scott 2009).

Efforts of the Christian Fundamentalist movement to remove evolution from high school science classrooms have focused on three points: (1) evolution (science) and creationism (religion) are incompatible; (2) evolution is a theory in crisis; and (3) it is only fair to teach both sides to students (Scott 2009). Upon further examination, however, these points all fail. Creation/intelligent design does not provide a scientific explanation. Many lines of evidence support evolution as both fact and theory.
People find a way to accommodate science and religion without conflict. In fact, Scott proposed the Evolution-Creationism Continuum to explain how slight variations in religious views place people along a continuum (http://ncse.com/creationism/general/creationevolution-continuum). National polling suggests that much of the US public falls somewhere in the middle—believing evolution happened, but that the process of evolution is somehow “guided by God” (Newport 2014). Such middle ground can allow for a great deal of acceptance, learning, and appreciation of the process of evolution, without the feeling that such learning automatically conflicts with religious beliefs. Such middle ground, however, is very different from relying on supernatural explanations and requiring a rejection of evolution.

**Finding Your Own Way**

*My work as an evolutionary biologist and education researcher has two goals: to elucidate how evolutionary processes operate to create, maintain, and erode biological diversity, and to elucidate how people construct their understanding of these processes. I certainly strive to be objective and rely on methodological naturalism in both endeavors. But I cannot remove myself entirely from the research, just as I suspect students cannot remove their previous experiences from their current learning.*

*Scientific knowledge must be based on evidence and be predictive, logical, subject to modification, and limited to explanations about the natural world. I do hope that as a student taking an evolutionary biology course, you come to realize that the question of whether evolution happens has been settled within the scientific community. Researchers today do not seek*
to establish whether evolution happened; rather, they seek to explore the processes and patterns of evolution. The evidence in support for evolution is overwhelming, has withstood over 150 years of testing, and is accepted by the scientific community.

Belief in the existence of God or gods is a personal journey. A connection to a power greater than ourselves can be comforting in times of suffering or provide guidance in difficult situations, but these powers cannot be tested. I therefore also hope you come to realize there are various models for bringing science and religion together, and not all of them require conflict, or redefining science. As Theodosius Dobzhansky wrote, “Seen in the light of evolution, biology is, perhaps, intellectually the most satisfying and inspiring science. Without that light it becomes a pile of sundry facts, some of them interesting or curious but making no meaningful picture as a whole” (Dobzhansky 1973). Dobzhansky also wrote in this same article, “I am a creationist and an evolutionist.”

**Acknowledgments**

My thanks go to Ben Roberts, Carl Zimmer, and Doug Emlen for responding to instructor requests and viewing this supplement as a useful document for many students taking evolution. Early conversations with them helped create the framework for this supplement. I’m also grateful to Emily Weigel and Jason Bundy for helpful discussions and comments on an early draft. Glenn Branch, Sarah Bodbyl Roels, and an anonymous reviewer also offered extremely valuable comments, strengthening all aspects of this work.
Additional Reading


Literature Cited


Edelsten, R. S. 1864. [no title]. *Entomologist* 2:150.


