CHAPTER 1

Science and/or Religion

The Primeval Atom

Consider two diametrically opposed creation stories, the first from ancient China and the second from twentieth-century Belgium:

> Long, long ago, when heaven and earth were still one, the entire universe was contained in an egg-shaped cloud. All the matter of the universe swirled chaotically in that egg. Deep within the swirling matter was Pan Gu, a huge giant who grew in the chaos. For 18,000 years he developed and slept in the egg. Finally one day he awoke and stretched, and the egg broke to release the matter of the universe. The lighter purer elements drifted upwards to make the sky and heavens, and the heavier impure elements settled downwards to make the earth. (Hamilton, 1988: 21)
>
> The radius of space began at zero; the first stages of the expansion consisted of a rapid expansion determined by the mass of the initial atom, almost equal to the present mass of the universe. The expansion took place in three phases: a first period of rapid expansion in which the atom-universe was broken into atomic stars, a period of slowing-down, followed by a third period of accelerated expansion. It is doubtless in this third period that we find ourselves today, and the acceleration of space which followed the period of slow expansion could well be responsible for the separation of stars into extra-galactic nebulae. (Lemaître, 1931: 422)

In these two quotations, we have stumbled onto a collision between religious and scientific accounts of the origin of the universe. While few contemporary Chinese and even fewer non-Chinese lend credence to the Pan Gu story, religious creation stories have nonetheless been enthusiastically embraced around the world and throughout history. Australia's aborigines believed that Baiame, the Maker of Many Things, brought up water, plants, animals, and even humans from underground to inhabit a previously barren, lifeless plain; the sun, moon, and stars came into existence when Emu and Eagle ancestors threw each other's eggs into the sky, and they burst into flames where they are continually fueled by Baiame (Parker, 1905). Mayans believed that Tepeu and Gugumatz *thought* mountains, trees, the sky, and animals into existence (Sproul, 1979: 285). Scandinavian tradition holds

that Odin, the All-Father and most powerful of the gods, made the earth from the flesh of the brutal frost giant Ymir, while the rivers and seas flowed from Ymir's blood (Sturluson, 1987). The Egyptian god, Khepri, spat out the gods She and Tefnut from his stomach and then united himself with them; when Khepri was united with She and Tefnut, he wept for joy, and from those tears humans arose (Sproul, 1979: 99). Perhaps the most influential, based on the number of people who believe it, is the creation story in Genesis: God *speaks* the world into existence out of nothing. God speaks and it is done (Genesis 1).

The account of "the creation" offered by Lemaître, a twentieth-century physicist, never mentions God. His account appeals only to an initial state (where time = zero), expansion, mass, and the tiniest of particles (such as protons, neutrons, and electrons). It assumes laws of physics, such as gravity and quantum forces. Imagine, according to Dr Lemaître, a universe contained within the casing of an exploding, cosmic firework, with its embers (galaxies) bursting forth in brilliant splendor. His view, which would be called "the Big Bang theory," requires only material particles and natural forces. Lemaître was the first physicist to demonstrate that all of the matter of the universe was, at the beginning, contained within an initial point, which he called "the Primeval Atom." Imagine, again with Lemaître, all of the matter of the universe squished uncomfortably together into a tiny point—smaller than the period at the end of this sentence. All of those tiny particles, like Aladdin crammed into his tiny lamp, were itching to get out. Lemaître called this point, likely without reference to the Chinese creation story, "the Cosmic Egg exploding at the moment of the creation." The Egg, which he also called "the Primeval Atom," was the birthplace of everything (Lemaître, 1950). When the Egg erupted, the particles of the universe rapidly expelled, but then, over billions of years, came together to form stars, planets, and galaxies. Like many scientists endeavoring into a new scientific field that yet lacks adequate language and concepts, Lemaître used metaphors. But his intent was to offer a completely scientific, completely natural, completely physical description of the beginning of the universe. Lemaître learned of the observational confirmation of his theory shortly before his death in 1966.

Prior to Lemaître, most scientists believed that the universe was infinite and eternal with matter relatively evenly distributed throughout, with the same unchanging shape and form forever. Lemaître argued that the universe was finite and temporal yet rapidly expanding and that, by mathematically tracing the expansion backwards, one could discover the very beginnings of the universe. The Big Bang occurred on "a day without yesterday," as he elegantly stated it.

On the one hand, we've got Pan Gu's Cosmic Egg and gods thinking or speaking things into existence and human beings created from divine tears while, on the other hand, we have science. Put this way, it is hard not to cast one's lot with science.

Religion and science are at war, no mere rumors here, and religion is losing all of the key battles. Or so it is claimed.

The Limitless Power of Science

Peter Atkins, professor of chemistry at Oxford University, assumes science and religion are in a conflict in which God has been decisively defeated. In so doing, he ironically treats science as a religion substitute. In his 1995 essay, "The Limitless Power of Science," Atkins assesses the status of religion in an age of test tubes and telescopes: "Science and religion cannot be reconciled, and humanity should begin to appreciate the power of [science] and to beat off all attempts at compromise. Religion has failed, and its failures should be exposed. Science, with its currently successful pursuit of universal competence . . . should be acknowledged the king" (1995: 132).

Any attempt to reconcile science and religion is, according to Atkins, "muddle-headed sentiment and intellectually dishonest emotion." Surprisingly, Atkins describes science in religious, even godlike, terms. Science is "limitless" (the Alpha and the Omega, the beginning and the end), and science "liberates" (the Truth shall make you free). Science will "blow back the fog that shrouds the mind of those who have not yet seen" (the Light of the world). Finally, sounding like a medieval theologian's omni-god (omnipotent, omniscient, omnipresent), Atkins commends "the omnicompetence of science." In a nutshell, says Atkins, "Science respects more deeply the potential of humanity than religion ever can." Science is the new sacred. God is out, Science is in. After apologizing for his exuberance, Atkins declares that it is not possible to be intellectually honest and believe in gods; likewise, he claims that it is not possible to believe in gods and be a true scientist. Religious belief, he concludes, is "outmoded and ridiculous" (1996).

Are we forced then to choose between outmoded, ridiculous religion on the one hand and omnicompetent science on the other? Does, for example, Lemaître's now widely accepted scientific theory stand in stark opposition to religion?

Father Lemaître

In 1927, Albert Einstein met Lemaître at a physics conference where the two discussed Lemaître's theory of an expanding universe. Einstein expressed his disagreement rather sharply. He was dubious partly because Lemaître's theory seemed too close to the Christian doctrine of creation. Lemaître, in addition to being a fine physicist, was also a Catholic priest. Since the opening sentence of the Bible suggests a beginning of the universe: "In the beginning God created the heavens and the earth," Einstein suspected the priest of smuggling God into his equations. Concomitantly, Lemaître's mentor, Sir Arthur Eddington, publicly declared Lemaître's claims about a beginning of the world "repugnant" (perhaps for antireligious reasons) (Farrell, 2005: 107). Sir Fred Hoyle, an award-winning British astronomer and physicist, long rejected Lemaître's Big Bang theory in part because it entailed a beginning to the universe (and if a beginning, then a creator). He disparaged belief in an exploding universe, declaring it, in a BBC interview

in the 1950s, as unseemly and undignified "as a party girl jumping out of a cake."

But in January 1933, Einstein, now a good friend of Lemaître, listened carefully at a seminar where Lemaître painstakingly presented the evidence for a beginning of the universe. At the conclusion, Einstein offered Lemaître a standing ovation, declaring, "This is the most beautiful and satisfactory explanation of creation to which I have ever listened" (Farrell, 2005: 115). Shortly thereafter, Einstein nominated Lemaître for the Franqui Prize, Belgium's highest award for scientific accomplishment. Einstein came to regard his rejection of an expanding universe as one of the biggest blunders of his life. Eddington, one of the twentieth century's greatest astrophysicists, would become Lemaître's biggest fan, commending his theories to other prominent physicists. Hoyle's later work on the generation of new elements through the evolution of stars (a central concept of the Big Bang theory) would move him from atheism to belief in a "supercalculating Intellect" (Hoyle, 1981).

Of course, Father Lemaître was keenly aware of the religious implications of his theory. In an unpublished paper written in 1922, five years before he published his first scientific paper on the theory, he claimed that that the universe had begun in light "as Genesis suggested it."[1]

Science and/or Religion

We started with primitive religious myths that were apparently refuted by science. But upon further inspection, some science, say the Big Bang, may confirm or coincide with religious myths. The relationship between science and religion may be more complicated than the claim to warfare makes readily apparent. While those like Atkins proclaim religion's demise at the hands of science, religion is still alive and kicking. To paraphrase Mark Twain, reports of religion's death have been greatly exaggerated. While science and religion may hit an occasional bump in the road, their differences may not be irreconcilable. The relationship between science and religion is, to be sure, complicated. And their courtship has been fraught with both peril and promise. But it is not all peril, as Atkins assumes.

Science and religion have mutually shaped our beliefs about the world. The way we dress and the food we eat, the methods by which we educate our children, and how we manage our health have all been influenced by both scientific discovery and religious commitment. Science may have proven that smoking is dangerous, but religions that prohibit smoking (such as Mormonism) are decidedly more effective in preventing smoking. Alcohol and drugs may likewise have negative health consequences, but Alcoholics Anonymous, with its reliance on a Higher Power, has proven to be one of the most successful cures for alcoholism and drug abuse. We have flown to the moon and split the atom; we can clone potatoes and, maybe one day, people. But we are soiling and maybe even destroying our planet at an astonishingly rapid rate with the very technology that has driven those remarkable

discoveries. Science, of course, may save us from ecological disaster and mutually assured destruction. But it may not. Science is not ("omnicompetence" aside) our Lord and Savior. And religion is here to stay (for better and, admittedly, sometimes for worse).

Better, then, to understand both science and religion, and their fascinating relationship, than remain in ignorance.

The claim that theism and evolution are incompatible assumes that *religion is a scientific hypothesis.* Richard Dawkins writes: "A universe with a God would look quite different from a universe without one. A physics, a biology where there is a God is bound to look different. So the most basic claims of religion are scientific. Religion is a scientific theory." Religion and science, then, compete on the same field. So Dawkins claims: "The existence of God is a scientific hypothesis like any other. . . . God's existence or nonexistence is a scientific fact about the universe, discoverable in principle if not in practice" (2006: 50). The great twentieth-century philosopher Willard Van Orman Quine concurs with Dawkins: "If I saw indirect explanatory benefit in positing sensibilia, possibilia, spirits, a Creator, I would joyfully accord them scientific status too, on a par with such avowedly scientific posits as quarks and black holes" (1995: 252). The God Hypothesis, Quine claims, is on a par with the periodic table of the elements, the kinetic theory of gases, Newton's inverse law of gravitation, the germ-theory of diseases, and quarks and black holes. We can lay them all alongside reality to see which measures up.

Many of our primitive (and not so primitive) ancestors did suppose God to be a scientific explanation of this or that. If theism were a scientific hypothesis, it would stand or fall by how well it explains the relevant scientific data. Such primitive peoples, requiring an explanation for thunder, postulated Zeus or Hadad; Aeolus or Vayu were thought to control the winds, while Tialoc or Chiuta brought on the rain; those in need of a little love could call on Cupid. There was no end of alleged deities in charge of reproductive success: Famian, Ison, Njambi, Ruhanga, Unkulunkulu, and Xesiovo, to name just a few. Even Aristotle called upon the Unmoved Mover to do some heavy planetary lifting. With the development of meteorology, the reproductive sciences, the principle of inertia, and the law of gravity, these gods have fallen by the intellectual wayside.

If God's existence is, as Dawkins claims, "unequivocally a scientific question," one must tot up the evidence for and against, and see how God fares. If God fares badly as a scientific explanation, then belief in God is rationally undermined. With respect to explaining the origin of species, Dawkins plumps for gradual evolution over divine design. The evidence, he claims, is "terminally fatal to the God Hypothesis" (2006: 61).

Is theism, the so-called God Hypothesis, a scientific hypothesis? I will occasionally revert to the colloquial usage of "God" for ease of communication and to remind ourselves that, unlike most scientific theories, the God Hypothesis involves propositions about a person, and to acknowledge that many believers treat belief in God more like belief in a person than a theory.[2]

Theism, at least for many modern believers, is not a scientific hypothesis, one in competition with the sciences of origins.[3] Many think that belief in God is more like belief in other minds (persons) than belief in a scientific theory such as the kinetic theory of gases or the structure of the atom. We don't believe in other minds (persons) as an explanatory hypothesis or scientific theory. We simply find ourselves believing in other persons, a belief that is an immediate product of our cognitive equipment, not the conclusion of an inference. We don't withhold belief in other persons until we observe a great deal of person-like behavior (thoughts, pains, feelings) and then, finally, affirm the belief as an induction from that set of data. Rather, we just believe in other persons. We can't do otherwise.

If God is a person, theism is not a scientific theory awaiting proof from physics or biology. If God is a person, one might simply find oneself believing in God through, say, religious experience or the testimony of those one loves and respects.

Belief in God is not, on this view, a scientific theory held tentatively or not at all until the available evidence piles up to confirm God's existence. Theism is not a scientific theory in competition with other scientific theories such as evolutionary theory. Even if evolutionary theory were well supported by the evidence, rational belief in God would not be precluded by it. Of course, various religious believers such as young earth creationists and Intelligent Design theorists do conceive of God as a scientific hypothesis in competition with evolutionary theory; such believers do, indeed, have a problem.

Dawkins and Quine (and others) may object and sternly assert that theism *is* a scientific hypothesis.[4] But it's religious believers' beliefs that are in question, not Dawkins and Quine's construal of their beliefs. And if the religious believer's belief is not a scientific hypothesis, then it need not await the decision of the scientific community or the accumulation of empirical evidence before she's permitted to hold it, and she need not fear that the accumulation of scientific knowledge will drive God into obsolescence. God is not competing with scientific theories because, at least for them, God is not a scientific theory.

Science cannot rule out the existence of the nonnatural, nor do (most) scientists try to do such a thing; but scientists cannot as scientists enter into discourse regarding the nonnatural. They are limited in their methods to the natural world and the natural processes found therein. God, if there is one, lies outside the naturalistic methodologies and measurements of science.

While God is the metaphysical explanation of why there is a world at all, God is not a scientific competitor with theories about how particular things work in the world. God is not a scientific explanation of some particular aspect of reality (like the motions of the planets or the origin of the species), God is a metaphysical explanation of everything. God, properly speaking, falls under the domain of the philosopher not the scientist. God is not on the scientific radar.

It's not the God Hypothesis that's defective. It's the assumption that God is a scientific hypothesis.[5]

Religion and the Sciences of Origins

We started with creation myths and the Big Bang because the religious rubber meets the science road in discussions of origins. In the development and reception of the Big Bang theory, we see the worry that the scientist-priest might be reading his religion into his data. We see the dismay on the part of some scientists that science might provide some sort of confirmation of an important religious doctrine, the doctrine of creation. Religious believers, on the other hand, are apprehensive because the sciences of origins keep offering naturalistic explanations that were once the special preserve of a supernatural God; when it comes to origins, science seems to keep trumping religion. And so there is the fear: the sciences of origins will crush God once and for all.

Rather than consider every issue in science and religion, I will focus, then, on the rubber meeting the road: on the sciences of origins.

Two topics will be obvious and have received the most attention in the past century: the origin of the universe and the origins of species (Big Bang cosmology and Darwinism). The former seems to corroborate belief in a creator, whereas the latter is often taken, by believer and unbeliever alike, to be clean contrary to belief in a creator.

Before we can discuss such issues in science and religion, we have to come to some sort of understanding of just what science and religion are. So we begin at the beginning with a quest for understanding both the nature of science and the nature of religion. We will learn that gaining such an understanding is not so easy.

Our first look at origins is a discussion of the origins of modern science. There we find deeply religious thinkers—Galileo, Newton, and Kepler, for example—grappling simultaneously with science and theology without the distinctions and fears of twentieth-century thinkers. At the very origins of modern science, we find science and religion deeply intertwoven both in the minds of the scientists and in the theories they are considering. Moreover, we can find in the theological reflection of these thinkers, resources for negotiating the relationship between science and religion.

While Darwin may have made the world safe for atheism, he, for most of his life, was not an atheist, and did not view his theory as a competitor to belief in God. After considering Darwin's religious beliefs (in relation to Darwinism), we move from the nineteenth- to the fourth century where we find St Augustine already puzzling over the proper interpretation of the biblical story of creation. Augustine suggests a profound way of reconciling the biblical creation stories in the Book of Scripture with scientific discoveries.

What precisely are the scientific discoveries that support evolution? What, in short, is the evidence for evolution? In "Evidence and Evolution" we examine two things: how the case for evolution is shaped and how precisely the case is made. From the perspective of religion, we are looking for clues as to how to read the Book of Nature, the companion book to the Book of Scripture. Of course, one might wonder how God could create a world if

the world is at bottom random (apparently out of God's control). That is the following chapter.

What does science say about the origins of religious belief itself? Is religious belief immune from scientific inquiry? Recent work in the cognitive and evolutionary psychology of religion affords insights into the operations of the human mind that incline us towards religious beliefs. But if belief in God involves a natural process, doesn't that somehow undermine rational religious belief?

In the next two chapters, we consider what science says about the origin of morality, and whether or not it leaves any room for God in one's understanding of goodness and the good life.

In "In Search of the Soul," we consider the source or origin of our humanity. While religious conceptions of the human person typically include an immaterial soul or spirit, recent work in the science of the brain has called the soul into question. We will look into the science of the mind and see what consequences it has for an understanding of ourselves as persons. We conclude with a discussion of the science of free will.

Finally, we return to the discussion that begins the book—the origin of the universe. The Big Bang suggests a consilience between the science of origins and the doctrine of creation. And the universe seems apparently exquisitely fine-tuned for the existence of life. Some have argued that this fine-tuning offers evidence of a Fine-Tuner.

The book concludes with two chapters, one each on Jewish and Muslim approaches to the science of origins. Owing to the cultural dominance of Western science and Christianity, discussions of science and religion are typically discussions of Western science and Christianity. It is time for consideration of these issues from the perspective of non-Christian religions. So while the main chapters primarily discuss Christian thinkers, and thinkers who played major roles in the development of modern Western science, we will conclude with a consideration of Judaism's and Islam's understandings of evolution.

CHAPTER 2

Conflict, Separation, Integration

CSI

One of the most popular television shows of the past decade is *CSI: Crime Scene Investigation*. Its wily supersleuths examine grisly crimes for the slightest of clues. Slowly, carefully, patiently, the clues emerge and then converge on the perpetrator. Grissom, the sagely veteran, repeatedly reminds his younger, impetuous investigators not to rush to a conclusion based on preconception, hasty judgment, or circumstantial evidence. He insistently and constantly reminds them: Don't focus on a single suspect, be open to surprising possibilities, and accumulate the evidence. Only when they heed his wise counsel are they able to discern the true pattern in their increasing and remarkably varied array of evidence.

"Conflict, Separation, and Integration" was a deliberately selected title for this chapter to remind us not to rush to hasty conclusions about the relationship between science and religion based on preconceptions, rushed judgments, or circumstantial evidence. We must proceed like Grissom on *CSI: Crime Scene Investigation*.

Most of us come to discussions of science and religion with preconceptions, typically armed with *conflict* metaphors such as "combat," "warfare," and "battle." This militaristic tone was set in the nineteenth century by influential books titled *History of the Conflict between Religion and Science* and *A History of the Warfare of Science with Theology in Christendom* (Draper, 1898; White, 1908). The casualty of this war: God. In less militaristic terms, belief in God is no longer an intellectually viable option. One need not look too hard to find a skirmish or two. In the United States, for example, the battle over beginnings (biblical creationism vs evolution) has been carried on in both the public square and the courts. Stephen Hawking has recently proclaimed that the law of gravity, not God, spontaneously created the world from nothing (Hawking, 2010). In the battle between gravity and God, gravity wins by a knockout. Hear biologist Richard Dawkins's assessment of Hawking's claim: "Darwin kicked [God] out of biology, but physics remained more uncertain. Hawking is now administering the coup de grace" (Dawkins, 2010). Conflict, it must be conceded, is the dominant metaphor.

What about *separation*? Religion and science also seem, sometimes or at least to some, quite separate or distinct from each other. For example,

physicist Freeman Dyson writes: "Science and religion are two windows that people look through, trying to understand the big universe outside, trying to understand why we are here. The two windows give different views, but both look out at the same universe. Both views are one-sided, neither is complete. Both leave out essential features of the real world. And both are worthy of respect."[1] Religion, according to this view, is more the home of ethics and the meaning of life; science, on the other hand, is concerned with how things go in the natural world. Religion is the world of value (how things ought to be); science is the world of facts (the way things are). Religion speaks of repentance, restoration, and reconciliation, whereas science speaks of atoms, absolute zero, and albatrosses. Science is concerned with things in the world, but God transcends the world. Pop-rock band Lone Justice's wistful lyrics "Soap, soup and salvation, tired hearts sing in jubilation, restoration at the rescue mission, soap, soup and salvation" tell of radically different persons, places, and things from the sober scientist in her laboratory carefully pouring from her beaker, poring over her notes, and deducing a natural law. No possibility for science–religion conflict there. Never the twain shall meet.[2]

Science and religion have also had, meaningfully and powerfully, *integration*. The science–religion twain have met and embraced. For Isaac Newton, as good a scientist as has ever lived, science and religion were the two threads of an intricately interwoven tapestry. Newton wrote: "This most beautiful system of the sun, planets and comets, could only proceed from the counsel and dominion of an intelligent and powerful being. This Being governs all things . . . as Lord over all."[3] Nineteenth-century physicist James Clerk Maxwell viewed his work as worship. He regularly prayed to God for increased wisdom so that he could better understand the work of God's hands (nature). The modern theory of genetics was discovered by Gregor Mendel, a Catholic monk who humbly and patiently observed successive generations of pea plants. Believing the universe to be the creation of a God of order, he did not believe hereditary characteristics were simply due to chance and sought to discover God's laws of inheritance.

So a little bit of conflict here, some separation there, and a dash of integration over there. Perhaps the relationship between science and religion is just plain messy: sometimes conflict, sometimes separation, and sometimes integration. It's not C, S, or I; it's C, S, *and* I. Before deciding how science and religion are related, one would do well to follow Grissom's advice: Don't focus on a single suspect, be open to surprising possibilities, and accumulate the evidence. Don't rush to judgment based on preconceptions or scanty evidence. You may very likely find yourself, as you do with the television show, surprised by a careful consideration of all of the evidence.

The purpose of this chapter is to canvass the various options—conflict, separation, and integration—for understanding the relationship between science and religion. But if we are going to address the relationship between science and religion, we must have some understanding of our subject matter: just what is science and what is religion?

Defining Science and Religion

Q: How many physicists does it take to change a light bulb?
A: Two. One to hold the bulb, and the other to rotate the universe.

Was that a good joke? For that matter, what is a joke? It is difficult to come up with a definition of "joke." Likewise it is difficult to define "science" and "religion." Whatever definition one comes up with for "joke," someone will quickly think of a joke that doesn't fit that definition. If we define "joke" as "a funny remark," we ignore the fact that some jokes are not funny. If we define it as a "remark intended to provoke laughter," we omit jokes that are actions without words (e.g., practical jokes or pantomime). If actions and intentions are included in the definition, applications to people or careers are left out, as in, "Richard Nixon's presidency was a joke." But if a person's life, such as Nixon's, can be a joke, the concept of a joke has been completely transformed: a life that is a joke is marked more by tragedy than humor. Moreover, Nixon never intended the tragedy. Our definition went from humorous remark, through intended humorous remark, to humorous act, and ended at unintended tragedy (and there are many more sorts of jokes than the ones I've just canvassed). By the time we got to Nixon, our definition of "joke" had none of the characteristics that we started with. There is no single definition of "joke" that contains all and only attributes of jokes. We know roughly what a joke is. We use the term. But we can't really come up with an adequate definition.

Science and religion are similarly afflicted.[4]

There are caricatures of science and religion at the outset: science is an objective, fact-oriented practice; religion is subjective and emotional. Where science is heralded as universal and based on objective observations in the world, religion is characterized by specific traditions based on subjective experience. The difficulty is coming up with a meaningful definition that includes all and only what we want it to include (and excluding everything we want to exclude). Should science include, for example, both Aristotle's biology and Einstein's $E = mc^2$? Should it exclude magic, astrology, alchemy (changing base elements like lead into precious metals like gold), and religion? And that's just science.

We start by taking a long look at scientists and their practices before taking a much briefer look at the definition of "religion." We will find, I think, that those whom we count as scientists and that which we call "science" can't be squeezed into any simple definition.

Science and Some Scientists

Defining "science" so that it includes exactly what it should throughout all of human history is complicated because science has included a great many beliefs, many of which are no longer held today, and scientific practices can differ wildly.

Throughout history "scientific" theories have held that the earth is at the center of the universe, that lead can be changed into gold, that the earth is only a few thousand years old, that the body contains four humors: blood, yellow bile, black bile, and phlegm (and that medicine, properly practiced, regulates the humors), that the earth is flat, and that various life-forms can be spontaneously generated out of nothing.

We can find a diversity of scientific practices as well, even in our own day and age. Imagine a white-coated scientist hunched over test tubes or peering through a microscope in a pristine, germ-free laboratory. He (our typical image of a scientist is, sadly, a male) makes very careful measurements, keen observations, and keeps meticulous records. After running hundreds of experiments, he ponders his numerical data and then applies very complicated mathematics. Soon a universal law of nature emerges. He adds this law of nature to the ever-increasing stockpile of confirmed laws of nature.

Is the work of the lab-coated experimenter—carefully deducing laws from observations, then adding his theory to the stockpile of science—the paradigm of science?

My father-in-law is a theoretical physicist. He seldom visits a laboratory and, when he does, he is there only briefly. In a lab, he is more tourist than technician. His tools of trade are a fountain pen and yellow legal pad. His "laboratory" is his imagination. He doesn't look out at the world; he sits at his desk and thinks. He "sees" the world in numbers and then jots down numerical patterns on paper. He derives theorems from fundamental axioms and assumptions. He believes the world, underneath all of its complexity, is simple and beautiful. Simplicity, beauty, and mathematical precision drive his scientific theorizing as much as, perhaps even more than, observations and experiments.

The greatest theoretical physicist of all, Albert Einstein, claimed that one of his best ideas came from thinking about what it would be like to ride on a beam of light. His general theory of relativity rejected the traditional view that light travels in a straight line, and he boldly predicted that light would bend around very heavy objects (like the sun). The solar eclipse of 1919 permitted the first testing of Einstein's prediction. So certain was he of the truth of his theory, Einstein couldn't be bothered to travel to Brazil or the island of Principe in Guinea where the observations would be made. When the results were announced, Einstein instantly became world famous. Einstein conducted his research in his mind, through thought-experiments, not in laboratories. He was guided by intuitions about the nature of reality not reflection on piles of observations. Of his method he said, "When I assess a theory, I ask myself, if I was God, would I have arranged the universe that way?" (Isaacson, 2007: 335). He was so convinced of the beauty and truth of his special theory of relativity that when he was informed that some new experiments refuted the theory, he questioned the experimental results rather than giving up his theory (and he was right—further experiments refuted those alleged to refute his theory).

While scientific theories came to Einstein in thought experiments, they came to others in dreams.[5] Otto Loewi (1873–1961), the Nobel-prize winning "Father of Neuroscience," first had the idea that nerve impulses were transmitted chemically in a dream. In the early 1920s, Loewi dreamed about an experiment that would show how nerve impulses were transmitted. Waking up in the middle of the night, he excitedly jotted the experiment down on paper and fell back asleep. However, the following morning, he couldn't read his own notes. But wait, wait; all is not lost. He had the same dream the next night. This time he attended carefully to his drowsy handwriting and quickly and correctly transcribed his Nobel-prize winning experiment.

Consider the caricature of Isaac Newton (1642–1727)—young Isaac got plunked on the head with an apple, thereby discovering gravity and going on to a great career in science. There is a grain of truth here: he likely did see apples fall on the family farm. Maybe he even saw falling apples as he was thinking about what kept the moon in its place and the relationship of the moon to tides. It took him years to calculate the law of gravity. Moreover, he didn't discover gravity—it's not as though people were floating around helplessly in space awaiting Newton's discovery! He did, however, discover the *law* of gravity, as well as the laws of motion, the light spectrum, and the calculus.

Newton also spent a great deal of his "scientific time" studying the Bible. Like many scientists of his day, Newton was involved in the illegal practice of alchemy—attempting to turn base elements, like lead, into gold. He wrote over a million words on alchemy, but they weren't made widely available until the twentieth century. Of Newton's alchemical research, physicist Arthur Eddington writes: "The science in which Newton seems to have been chiefly interested, and on which he spent most of his time was alchemy. He read widely and made innumerable experiments, entirely without fruit so far as we know" (Eddington, 2007: 69). In fact, Newton's discoveries of the theory of gravity and the nature of light may have arisen out of his alchemical research (not from the mythical apple). Newton fervently studied Scripture because he believed that the secrets of alchemy were hidden in and then transmitted through various sacred writings. He believed that various supernatural agents had long ago passed on this alchemical wisdom to earthly emissaries like Moses who then passed them on to successors including Pythagoras and Plato. Newton cautioned his contemporaries who had likewise embarked on alchemical research to remain silent on the topic because it was feared that whoever held the secret of the transmutation of lead into gold would be strangled in his bed to extract the secret.

In the seventeenth century, alchemy was called "chymistry" from which we get our term "chemistry." Since chemistry arose from chymistry, and since the first chemists were also chymists, it is difficult to define "science" so that it includes chemistry but excludes chymistry (i.e., alchemy).

Aristotle (384 BC–322 BC), often referred to as "the father of today's scientific method," wore no lab coat, didn't darken the door of a laboratory, used no microscopes or telescopes, and came up with exactly zero laws of

nature. Yet he was the greatest scientist of his day and his theories dominated science until the sixteenth century.[6] Ancient and medieval physics was Aristotelian physics. Ancient and medieval biology was Aristotelian biology. Medieval scientific method was Aristotelian. Yet virtually every aspect of Aristotle's physics was rejected during the scientific revolution, and most of his biology was rejected by Darwin. While he did endorse some sort of empirical method (which relies on sense experience), his naïve but understandable reliance on the senses and common sense were shown to limit scientific inquiry.

Aristotle was the teacher of Alexander the Great (356–323 BC), King of Macedonia, one of history's great military geniuses. Through a series of remarkable military conquests, Alexander extended the Macedonian empire from north Africa through Europe and into India—the largest in the world. Legend has it that Alexander wept because he had no more worlds left to conquer. Yet upon Alexander's death, Macedonia was plunged into civil war, was besieged by outside forces and, in 146 BC, was reduced to a Roman province. Aristotle's science and scientific method, like Alexander's empire, have disappeared from the world. Yet it would be folly to exclude Aristotle's work and beliefs from science by definition.

Of course, not all scientific discoveries are made through dreams, through alchemical secrets, or by reading the mind of God. Many scientists, at least in the late twentieth century and later, work in laboratories and assiduously collect data. Some test predictions made by a theory. Some are more exploratory. But these quirky examples, and the study of history, show that if we define science too narrowly so as to exclude alchemy, religion, hunches, and educated guesses, we may end up excluding, for example, Newton, Aristotle, and early physics and chemistry.[7]

Science, Natural Philosophy, and *Scientia*

If our definition of science must include all of the above, we shall have no easy task.[8] From Archimedes and Aristotle, on the one hand, to Newton and Einstein, on the other, there is no single method or even common field of inquiry. The term "scientist" itself was not invented until the nineteenth century (Ross, 1962: 71–72) and even then it was introduced as a joke (since we don't know exactly what a joke is, we don't know if "scientist" could have been meant as a joke!). The term didn't catch on until the beginning of the twentieth century. Until the word "scientist" stuck, those who sought an understanding of nature referred to themselves as natural philosophers. While *we* might call Newton a scientist or physicist and his writings "science" or "physics," he did not. He didn't entitle his most famous work *Principles of Science* or even *Principles of Physics*. Newton's greatest work was *The Mathematical Principles of Natural Philosophy* (*Philosophiae naturalis principia mathematica*—usually referred to simply as "Principia"). Newton was, by his own account, a natural philosopher and considered his results natural philosophy. We impose, anachronistically, the term "science" and "scientist" when we apply them to

pre-twentieth-century thinkers. In so doing, we impose what we now think is proper science and what we now think are proper scientific methods into domains where they simply don't apply.

The Latin *scientia,* from which we get the term "science," simply means "knowledge" or "certainty" and in the Middles Ages included anything about which humans have attained the highest level of confidence; *scientia* is a true and certain knowledge of reality. Historically, *scientia* was not restricted to the natural world but included ethics (moral philosophy), metaphysics, and theology. Various medieval thinkers thought that one could acquire, after very extensive and careful study, *scientia*—certain knowledge—about such statements as "Keep your promises," "The interior angles of a triangle total 180 degrees," "God loves you and has a wonderful plan for your life,"[9] and "Nothing can be completely red and completely green." Natural philosophy, what we might rather call "science," was organically related to (not distinct from) all of those other disciplines in the unified domain of *scientia*; it was just one more item of knowledge in the big pile of human knowledge. For the medievals, there is nothing special that distinguishes natural philosophy, what we might now call science, from other fields of knowledge, including theological knowledge, in that pile.

Yet, in our day and age, it is impossible to deny that there is something special and even distinctive about science. What is it, then, that defines science and makes it so special?

Defining Science

We sometimes think of scientists as special, almost priestly, people who study a very special, almost sacred, topic. I think we can agree that science is special and that it is not just any old piece in the pile of knowledge. The universal law of gravitation and the germ theory of disease are somehow better than more ordinary knowledge claims such as "I had oatmeal for breakfast" and "Wow, that sunset sure is pretty." Some go further: they consider it the highest form of human knowledge; some have even considered it the *sole* form of human knowledge. But we don't need to go that far to concede that science is a uniquely special and important sort of human knowledge and inquiry.

The image of the contemporary scientist in the laboratory conveys the following ideas about the nature of science:

1. Science is *empirical*—it is both beholden to and restricted to information gained from our five senses.
2. Science is *objective*—there are no subjective factors involved in scientific judgment.
3. Science is *cumulative*—the history of science is the progressive accumulation of knowledge with each success simply an addition to previous successes.

Let us briefly consider these.

Science Is Empirical?

Science, you might think, is just the simple accumulation of empirical, objective facts. But while empirical facts are surely the touchstone of science, most scientific theories are not limited to what can be observed; they often involve explicit reference to various unobservable entities or powers. A scientist may start with trees, planets, and radium, all of which can be clearly observed. But they quickly move to the unseen realm of genes, gravity, and atoms. Scientific theories often invoke these extraordinary and unseen things and forces to explain the things that we can see. Even when scientific laws are restricted to things that can be seen, such laws apply to the vast regions of space and the distant past and future, so their content involves things that no human being could possibly see. For example, the law of universal gravitation states that every body in the universe is attracted to every other body in the universe (in direct proportion to their masses and indirect proportion to their distance from each other). This is true for *every* body in the universe at *every* time (past, present, and future). We—even if we include every human who has ever existed—could never see into the vast reaches of space, or into the past or into the future. Every body in every place at every time—such is the subject matter of the universal law of gravitation. So scientific theories and laws go vastly beyond what any human or any group of humans could possibly observe. Science may start with the observable, and it may be answerable to the observable, but it certainly does not end with the observable.

Thinking of infinite realms beyond what humans could possibly experience is science's charm and curse. Not curse in a bad sense—curse in the sense that it is very, very difficult to comprehend the reality that exceeds our five senses.

Imagine that you, for the first time in your life, are sailing across the surface of a vast and deep and beautiful ocean. As the sun glints off its silver surface, you can't visually penetrate its dark underside. You reach out and touch the limpid surface; it feels cool, silky, and liquid. Then, breaking through its skin, you delve below. Your grasp is limited to the length of your arm—a couple of feet at most. You feel around—only water strikes your fingertips. You bring the water to your nose and smell vague, some identifiable and some unidentifiable, scents. What lies below is mystery. You look all around and, as far as you can see, there is water everywhere. Beyond the horizon lies what? Beneath the surface contains what?

Science is like that. We seek to peer beneath or behind or beyond what we can see, hear, touch, taste, or smell to the secret springs and powers that cause our perceptions. We gaze beyond the present toward the horizons of the past and future, seeking principles that apply at all times. And we look at the universe from our little point within a point within a point, seeking laws that hold true throughout entire cosmos. We constantly return to what we can experience—experience *is* our touchstone to reality—but it is just our starting point. Science beckons us beyond the bounds of finite human experience.[10]

Science Is Objective?

As every scientist well knows (but few publicly concede) subjective evaluations are essentially involved in scientific theorizing. While scientists aim at the truth, the target is not easy to hit. And it can't be hit with a quiver of observable data alone. Even running observable data through the filter of "the scientific method" won't hit the target. Some of the most brilliant thinkers in human history have attempted to grasp the nature of reality and been woefully mistaken. Science is just plain hard—it requires a grasp of a huge amount of data, the ability to think very abstractly and often in defiance of common sense, and very high-level mathematics. If science were easy—if there were some easy, rule-based, foolproof system of moving from the seen to the unseen—humans would have discovered quantum mechanics and the structure of the DNA molecule long ago (and with a lot less effort).

Even conceding our limitations, there's another problem for developing the true scientific theory on the basis of observation. Many competing theories are consistent with any set of observations. The data don't point unequivocally in the direction of a single theory. And so other factors, *value judgments*, are called upon to decide which theory is the "best explanation" of the relevant data (Kuhn, 1977; McMullin, 2012).

Consider an example. Suppose that you are a physicist trying to explain quantum phenomena—the stuff that atomic bombs and lasers are made of. According to contemporary physics, this quantum stuff is notoriously unpredictable. So scientists postulate unseen and unseeable electrons that hop, skip, and jump around inside atoms in a random manner; no scientific law could capture this carefree motion. But while electrons are widely accepted, various entities could fully account for all of the data. Scientists initially postulated that quantum phenomena are produced by the smallest pieces of material reality: invisible and indivisible pieces of matter called atoms ("atom" in Greek means "indivisible"). These entities, in turn, constitute the ultimate building blocks of reality. Some believe protons, neutrons, and electrons themselves are actually further divisible into even tinier pieces of matter called quarks. Others believe that the most basic units of reality are not pieces of matter at all but are packets of energy. And, given certain wave-like, particle-like behavior of the apparent cause of quantum phenomena, others believe that ultimate reality is a wave-particle. So far we've got, as the ultimate building blocks of reality: protons, neutrons, and electrons, or quarks, packets of energy, or wave-particles. Theories involving each of these entities could be made fully, mathematically consistent with the data (of course, they may require some tinkering). And we're just getting started. A vast number of other theories could account for quantum phenomena. Contemporary scientists limit their imaginations because they are committed to theories in terms of matter and energy (or matter/energy) and their various manifestations. So contemporary theories exclude nonmatter/energy explanations of quantum phenomena at the outset.

However, ultimate, unseen reality may not be matter and energy at all; it could be really, really small person-like things that, like most persons, behave capriciously (I don't offer this as a serious option; it's just a logical possibility).[11] Teeny, tiny elves dart about in this unseen world in a manner captured by the mathematics of quantum theory. Except for prejudice (prejudgment, which is not always bad, certainly not in ruling out tiny elf theory) against persons as the causes of material reality, we might have seen twentieth-century scientists develop elvic theory instead of atomic theory. I'm not commending elvic theory over atomic theory, but a theory involving elves *could* account for the observable data as effectively as atomic theory. A value commitment to *material causes*, not simply reflection on the observable data, has guided us toward favoring atomic theories. But even commitment to material causes is not sufficient to settle whether wave-particles, packets of energy, or indivisible matter are the ultimate stuff of reality.[12]

We've already seen one value commitment that guides scientific theorizing—a commitment to explanations in terms of matter and energy (in their various manifestations). But there is a host of other values that scientists rely on to sort through the huge number of competing theories that could fully account for the empirical data.

For example, scientists bring to the evaluation of the data a commitment to *simple* theories; they embrace the adage that *the simple is the sign of the true*. But perhaps reality is extraordinarily complex and the assumption of simplicity is systematically misleading. Scientists also prefer theories that are *fertile*—theories that suggest or unite other domains of research. But, again, reality may be dappled and disjoint with lots of unrelated things and our quest for unifying explanations, again, may be systematically misleading.[13]

Scientists also prefer theories that are *beautiful*—the true is the beautiful, according to this view. Paul Dirac, Nobel-prize winning physicist, once advised his students to be concerned only with the beauty of their theories (Weinberg, 1994). When Watson and Crick discovered the structure of the DNA molecule, Watson wrote that some found the DNA's double-helical structure "too pretty not to be true" (Watson, 1968: 124). In his *Dreams of a Final Theory*, Steven Weinberg, again a Nobel laureate in physics, contends that beauty will be a defining characteristic of the final, absolutely true, scientific theory of the world: "When it turns out that mathematically beautiful ideas are actually relevant to the real world, we get the feeling that there is something behind the blackboard, some deeper truth foreshadowing a final theory that makes our ideas turn out so well . . . The beauty in our present theories may be 'but a dream' of the kind of beauty that awaits us in the final theory." Beauty, to follow the theme of this chapter, compounds the problem of the definition of science: "professionals have stopped using this word [beauty] because they realize how impossible it is to define . . . you do not define these things; you know them when you feel them" (Weinberg, 1994: 6, 17, 134).

Commitments to matter/energy, simplicity, fertility, and beauty are not forced upon us by the objective data. We don't observe them in or infer them from the world, *we bring them to the world* and use them to assess the data. Such values guide scientists in their assessments of various theories. They are necessary precisely because the empirical phenomena can be accounted for perfectly adequately by a wide variety of complex, disjointed, and ugly theories that invoke any number of entities as the ultimate sources of reality. But the fundamental conviction that the world must be a certain way—simple and beautiful, for example—guides our understanding of the observable data. Because science involves values as well as observations, it is not a purely objective discipline. Yet let us remind ourselves that the use of subjective values has not prevented scientific discoveries of the first order. In fact, it is only through the judicious use of such values that scientific discoveries are possible at all.

Science Is Cumulative?

Many people assume that science is cumulative, and that each new piece of scientific knowledge is added to the top of the ever-growing pile of scientific knowledge. But science is not the simple accumulation of fact-based hypotheses. Newton's physics overthrew much of Aristotle's, and Einstein's physics overthrew Newton's. Darwin's biology was a rejection of much of Aristotle's. There are serious inconsistencies in contemporary physics, and these inconsistencies suggest the possibility of a radically new theory. So there may be a greater-than-Einstein who offers a new theory that leads to the rejection of the theories of both Einstein and Darwin.

Scientific theories are subject to radical change as scientists discard old hypotheses, methods, and assumptions.[14] In attempting to define "science," we often ignore the fact that today's science is the result of a long chain of wrong but brilliant guesses. Items that were once considered absolutely central to the best scientific theories of their day have been consigned to the trash heap of knowledge, from things like phlogiston, crystalline spheres, and the caloric to forces like *vis viva*, impetus, and astrology.[15] Don't worry if you aren't familiar with these (I'm just making a point): they were once the stuff of well-established theories. In their day, every well-educated person, including persons we now call "scientists," firmly believed in them. They are now just quaint (and mostly unknown). They weren't preserved in the sciences that succeeded them; they were simply discarded.[16]

Science is not strictly speaking empirical, objective, or cumulative. Moreover, values like simplicity and elegance play a role in the acceptance of theories.[17] Yet none of this has precluded scientific knowledge (though it has muddied our understanding of what precisely science is and how it is practiced). Let us illustrate the success of science, and its use of values like simplicity and elegance, with an actual example, the sixteenth-century discussion of the nature of the cosmos.

Simplicity and the Center of the Universe

The historical debate about the center of the universe illustrates how science is not strictly empirical, objective, and cumulative. Since this debate also figures in the science–religion discussion of the next chapter, it will be useful to consider here. Prior to, say, 1600 AD virtually every Western astronomer believed that the earth was at the center of the universe (which, sadly, 20% of Americans still believe [Crabtree, 1999]): all of the stars, planets, and the sun, like the moon, revolve around the earth. The evidence for this view is, well, evident. Sit outside one evening, focus your gaze on the heavens, and *see* the cosmos revolve around you. Moreover, you don't *feel* the earth move. It was widely believed, following Aristotle, that material things (all made of the element Earth), seeking their "natural place," fell toward the center. Since all earthy things fell toward the earth, the earth was the center. Finally, it was widely believed that heavenly motions, being heavenly, were perfect. Since astronomers believed that the most perfect motion was circular, they also believed that everything revolved around the center point (the earth) in perfect, circular motion. Again, when you are gazing at the heavens at night, you will see the stars and planets arc around the earth in perfection—circular motion. Aristotle's view of the cosmos was systematically and mathematically developed by Ptolemy in the second-century AD. The Ptolemaic system was widely accepted, with an amendment here and there, until around 1600 AD. At the center of the Ptolemaic system—both literally and figuratively—was the earth.

But as observations accumulated, the earth-centered system grew vastly more complicated, even unwieldy.

The earth-centered system would find its final expression in the work of Tycho (pronounced "Teeko") Brahe (1546–1601). So great was Tycho's reputation that the King of Denmark gave him an island and funds to build an observatory. He was determined to improve on the observational foundation of astronomy—no more amateurs relaxing in their backyards gazing at stars. He dramatically improved instruments, in this pretelescope era, for observing and measuring the stars and planets. The observations of Tycho and his many assistants were 10–30 times more accurate than previous astronomical observations. His improved observations made it increasingly difficult, mathematically, to model the solar system with the earth at its center. Copernicanism—the view that the sun is at the center of the universe—was a controversial but live option for astronomers of his day. But Tycho couldn't bring himself to believe that the earth was not at the center of the universe or that the earth was in motion.

Nonetheless, Tycho's new and improved observations led him to reject Ptolemy's simple, earth-centered, circular system. In Tycho's system, while the important things—the sun, moon, and stars—rotated around the earth, Mars and the other planets orbited around the sun. Tycho's system was mathematically no better than Ptolemy's system. Both could equally well account for all of the observable data.

In 1600 AD, in order to complete the new calculations of the orbits of the planets, Tycho hired a more mathematically adept astronomer named Johannes Kepler (1571–1630). The two had had a stormy relationship. The younger scholar repeatedly insulted his elder and Tycho was concerned that Kepler would use his data to discredit the earth-centered system that he had defended. Upon Tycho's death a year later, his fears were realized: Kepler coopted Tycho's massive set of observational data that he had carefully collected for over 40 years.

Kepler then used Tycho's observational data in defense of the Copernican system. Kepler improved on Copernicus's system when he realized that the planetary orbits were not perfect circles as Copernicus (following Aristotle) supposed, but were instead "flattened circles" (ellipses). The chief virtue of Kepler's system: it is mathematically simpler than the earth-centered systems of Ptolemy and Tycho.[18]

Aside from simplicity and elegance, though, the Ptolemaic, Tychonic, and Copernican systems could account equally well for the observational data.[19] There is no mathematical advantage, other than simpler calculations, of the sun-centered view of the cosmos over any earth-centered view. The three systems are mathematically equivalent, and identical predictions can be made within any system. As far as the observations go, there is nothing to recommend one system over the other—you have to bring in nonobservational values like simplicity and beauty. On those grounds, the Copernican system, as modified by Kepler, wins hands down over the Ptolemaic system.

Science, though not a rule-governed process, is remarkably successful in discovering the truth. However science works and whatever its precise definition is, we know that the earth rotates around the sun, that the heart is a pump that circulates blood throughout our bodies, that diseases are sometimes caused by germs, that gases expand when heated in accordance with Boyle's law, that light is made up of many colors, that the basic elements arrange themselves very neatly into the periodic table, that the universe is billions of years old, that $E = mc^2$, and that all biological species evolved from a single ancestor. Science is, without a doubt, one of the most astounding of all human intellectual achievements.

So What is Science?

When a contemporary scientist makes a creative guess, he or she formulates that guess into a hypothesis and then the hypothesis is put to some sort of test. The sorts of tests that hypotheses are subjected to can be very rigorous, involving incredibly complex equipment; these tests are often repeated. The sorts of tests involved vary depending on the science and the hypothesis. A test of a hypothesis for the destruction of dinosaurs will be completely different from a test for the existence of black holes, the special theory of relativity, or the structure of the DNA molecule, each of which in turn requires its own specific means of evaluation.

Scientists today invent hypotheses and put them to various tests. That's about all we need at this point in our understanding of the scientific process. This is sometimes called *the hypothetico-deductive method*: scientists come up with various testable hypotheses (by whatever creative and mysterious processes are involved in the imagining of new theories). Testable predictions or consequences are then deduced from the hypotheses. At that point, an experimental scientist takes over: he or she seeks to confirm or deny the hypothesis based on its testable predictions. While many accept the hypothetico-deductive method as the "true" scientific method, others reject it.[20] Moreover, it does not apply to all of the instances of what we might call science throughout human history. Yet it is as good as any definition of the current practice of science.

As we proceed in our discussion, though, we can look more at the *results* of the practice of science than at the *process* or *definition* of science itself. We will consider, for example, where some particular claims of well-established science is alleged to be in conflict with or to support some claims of religion.

Defining Religion

We have seen the difficulty of defining "science." Are we any better off in defining "religion?" I was once at a conference with a group of theologians discussing the nature of religion. After several academic and abstract definitions, the earthy theologian Stanley Hauerwas exclaimed, "That's a pile of horseshit. I'll tell you what religion is. Religion is a farmer sittin' on his stool readin' his Bible." Taken literally, that definition is likewise a pile—it restricts religion to so-called "religions of the Book" and, very likely, to Christianity. Taken metaphorically, it may mean that religion involves deeply human ritual practices in response to the divine. But like science, religion cannot be bundled into a neat word or phrase that concisely describes its many facets. In 1990, the Barnes and Noble Cambridge Encyclopedia stated that "no single definition will suffice to encompass the varied sets of traditions, practices, and ideas which constitute different religions." The difficulty in defining "religion" parallels the difficulty in defining "science"—there is no single definition that can capture everything we mean when we use the word "religion."

In the West, religions are widely associated with belief in or beliefs about gods or even God (Yahweh, the Father Almighty, or Allah, most notably). But if the definition of religion were to require god beliefs, then the Buddha and some Buddhists (those who, following the Buddha, are atheists) would not be religious.[21] Some religions, such as Buddhism, essentially involve proper behaviors. Others, such as various forms of Gnosticism, involve esoteric knowledge and show little concern for human behavior; these religions are more concerned with having proper beliefs rather than proper practices. Some religions, such as Roman Catholicism, have a highly hierarchical priesthood, while others, say Quakers, are more egalitarian. Some forms of

religious Confucianism are completely private (the rituals take place within one's own home). Some, such as Protestant Christianity, involve a set of authoritative texts and doctrinal beliefs, while others, Sufi mystics, for example, reject such linguistic barriers between the individual and transcendent, ineffable reality. Some involve highly articulated liturgical practices such as the burning of incense, singing of choirs, and hoisting of holy books at the precisely right moments. Quakers, on the other hand, sit together in silence during worship. Others, such as shamanistic ecstatic religions, involve more chaotic, feeling-driven, body-shaking practices. From such widely varying beliefs to such vastly diverging practices, it is hard to fit all of religion under a single umbrella.

Philosopher William Alston, after analyzing various definitions of religion, finds them all wanting because no single definition can fit every case of what we might consider religion (Alston, 1967). Instead of thinking of religion in terms of a single, unifying definition, he suggests a web of "religion-making characteristics." These sorts of characteristics, some of which are partly overlapping with others, tend to make something count as a religion. These characteristics include the following:

1. Belief in supernatural beings.
2. A distinction between sacred and profane objects.
3. Ritual acts focused on sacred objects.
4. A moral code believed to be sanctioned by the gods.
5. Characteristic religious feelings (awe, sense of mystery, and adoration).
6. Prayer and other forms of communication with gods.
7. A worldview, or general, picture of the world as a whole, and the place of the individual therein.
8. A more or less total organization of one's life based on the worldview.
9. A social group bound together by the above.

This list is not exhaustive. Moreover, a religion could have as few as one and as many as nine of these characteristics.

No need to belabor the point: it's impossible to define "religion" in a handy, single, useful, and comprehensive way. But if we can't adequately define "science" and "religion," how can we hope to understand the relationship between science and religion?

The Relationship between Science and Religion

We've been so far unsuccessful in precisely defining "science" and "religion" so that they fit all times and all places. Yet this book is about science and religion. What gives? Surely some claims of some actual religions are relevant to science (by some definition). Instead of talking about religion and science in very general terms, let's restrict ourselves to something more manageable—the specific claims of a single religion, Christianity, and the specific claims of modern, Western science.[22] So instead of talking about

science in general (which can't be precisely defined) and religion in general (which can't be precisely defined), we will talk about specific scientific claims, such as the law of universal gravitation or the age of the earth, and their relationship to specific Christian beliefs or doctrines, such as divine creation or divine providence. Let's put this together into more useful questions: How have science and Christianity been related? How are, can, or should they be?

There are various options, as mentioned earlier in this chapter, for conceiving of the relationship between science and religion. Some hold that science and religion are fundamentally in conflict. Others hold that science and religion occupy distinctively separate, nonoverlapping realms (and so couldn't possibly conflict). And still others, like Kepler and Newton, believed that science and religion can be integrated together in mutually beneficial ways. These general positions—conflict, separation, and integration—are three main ways to interpret the complex relationship between science and religion.[23]

> *Conflict*: Science and religion are in continual conflict, both historically and fundamentally.
> *Separation*: Science and religion are entirely independent, and operate within separate realms.
> *Integration*: Science and religion are fundamentally related, and can correct and enhance each other.

Let us briefly consider these three models of the relationship between science and religion.

Conflict

Reflecting on the travails of Galileo and the reception of Darwin, it is fashionable to assert that science and religion are locked in mortal combat. Such high-profile examples are seized upon in historically influential but deeply flawed and misleading books such as John William Draper, *History of the Conflict between Religion and Science* (1874) and Andrew Dickson White, *A History of the Warfare of Science with Theology in Christendom* (1896). Of Galileo, Draper wrote:

> Galileo was accused of heresy, blasphemy, atheism. He was summoned before the Holy Inquisition, under an accusation of having taught that the earth moves round the sun, a doctrine "utterly contrary to the Scriptures." He was ordered to renounce that heresy, on pain of being imprisoned. He was directed to desist from teaching and advocating the Copernican theory, and pledge himself that he would neither publish nor defend it for the future. Knowing well that Truth has no need of martyrs, he assented to the required recantation, and gave the promise demanded.
>
> For sixteen years the Church had rest. But in 1632 Galileo ventured on the publication of his work entitled "The System of the World," its object being

> the vindication of the Copernican doctrine. He was again summoned before the Inquisition at Rome, accused of having asserted that the earth moves round the sun. He was declared to have brought upon himself the penalties of heresy. On his knees, with his hand on the Bible, he was compelled to abjure and curse the doctrine of the movement of the earth. What a spectacle! This venerable man, the most illustrious of his age, forced by the threat of death to deny facts which his judges as well as himself knew to be true! He was then committed to prison, treated with remorseless severity during the remaining ten years of his life, and was denied burial in consecrated ground. (Draper, 1898: 171–72)

This sounds bad for any hope of reconciliation between science and religion.[24]

Of Darwin, White wrote:

> DARWIN'S *Origin of Species* had come into the theological world like a plough into an ant-hill. Everywhere those thus rudely awakened from their old comfort and repose had swarmed forth angry and confused. Reviews, sermons, books light and heavy, came flying at the new thinker from all sides.
>
> The keynote was struck at once in the *Quarterly Review* by Wilberforce, Bishop of Oxford. He declared that "the principle of natural selection is absolutely incompatible with the word of God"; that it "contradicts the revealed relations of creation to its Creator." Nor did the bishop's efforts end here; at the meeting of the British Association for the Advancement of Science he again disported himself in the tide of popular applause. Referring to the ideas of Darwin, who was absent on account of illness, he congratulated himself in a public speech that he was not descended from a monkey. The reply came from Huxley, who said in substance: "If I had to choose, I would prefer to be a descendant of a humble monkey rather than of a man who employs his knowledge and eloquence in misrepresenting those who are wearing out their lives in the search for truth." (White, 1908: 70).

Such combative and pugnacious language is widely accepted as the god-honest truth.[25]

Suppose we take these exaggerations and half-truths as the whole truth and nothing but the truth. Two examples scarcely amount to a fundamental or continual conflict between science and religion. Cases of actual conflict between science and Christianity are few and far between. The conflict thesis gains momentum by dramatizing and emphasizing relatively few and typically exaggerated historical events.

Yet there surely is conflict sometime between some science and some religion. For example, young earth creationism blatantly contradicts the science of a very old earth. The scientific consensus that humans descended from preexisting species conflicts with the widely held belief that humans were created by a direct act of God breathing life into dust.

But the myth of continual and irreconcilable differences needs to be put to its well-deserved final rest.

Separation

Imagine Muhammad Ali versus Smokin' Joe Frazier in the Boxing Match of the Century. Ali, dancin' like a butterfly and stingin' like a bee, throwing and landing countless clever jabs, amazingly, is seldom hit. Smokin' Joe lumbers around the ring delivering punch after powerful punch but, again, is the recipient of scarcely a blow. At the end of the final round, the bell rings and both Ali and Smokin' Joe are declared the winner. How could that happen? Turns out, they were boxing side by side but in entirely different rings.

Maybe science versus religion is like this imaginary boxing match. Perhaps science and religion are not in conflict because they aren't in the same ring. Perhaps science and religion are wholly independent of one another. They don't actually conflict with each other because they *can't* conflict. According to the separation model, science and religion cannot step on each other's toes because they walk within totally isolated realms. Science and religion address different issues and answer different questions using different methods and different languages.

One version of the separation model holds that science and religion have different foundations: science rests on human observation and reason, religion rests on divine revelation. In a *National Geographic* issue that included an article on the evolution of life, the editor offered his view on science and religion:

> Faith and science have at least one thing in common: Both are lifelong searches for truth. But while religion is an unshakable belief in the unseen, science is the study of testable, observable phenomena. The two coexist, and may at times complement each other. But neither should be asked to validate or invalidate the other. Scientists have no more business questioning the existence of God than theologians had telling Galileo the Earth was at the center of the universe.
>
> Bill Allen, *National Geographic*, March 1998

The editor holds that since science and religion have different methods and start from different foundations, their beliefs *can't* conflict (they might even complement one another).

The recently deceased Harvard biologist Stephen Jay Gould proposed that science and religion belong to separate domains, which he calls "nonoverlapping magisteria" (NOMA, for short). Nonoverlapping magisteria is "a principle of respectful noninterference." Gould writes: "The lack of conflict between science and religion arises from a lack of overlap between their respective domains of professional expertise—science in the empirical constitution of the universe, and religion in the search for proper ethical values and the spiritual meaning of our lives. The attainment of wisdom in a full life requires extensive attention to both domains" (1997). Because science and religion inhabit such different arenas of thought, each serves a different purpose in human life and inquiry. Science operates within the domain of the *how*; that is, science aims to discover the ways in which

things operate—science explores *what is*. On the other hand, religion operates within the domain of the *why*, answering questions about meaning and purpose—religion explores *what ought to be*. The separation model avoids conflict and preserves the unique aims of both science and religion.

Religion, the domain of value and meaning, can help us to change ourselves for the better and to become other-regarding. The magisterium of religion governs self-understanding, our hopes and fears, choices, decisions, personal crisis, meaning, relationships, morality, miracles, and virtue.

Science, the ream of natural facts, can say little of the existence of miracles, morality, and deities. It can neither affirm nor deny the existence of a supernatural creator. While science may influence the way that some people live and understand their lives, it does not require those who study it to adopt a naturalistic worldview. Science helps us to understand objective truth both in the cosmos and at the molecular level. Scientific answers are observable and repeatable. Ultimately, science is limited to the observable, the measurable, the tangible.

By restricting science and religion to their own magisterium, conflict is avoided. Gould states that, "If religion can no longer dictate the nature of factual conclusions properly under the magisterium of science, then scientists cannot claim higher insight into moral truth from a superior knowledge of the world's empirical constitution. This mutual humility has important practical consequences in a world of such diverse passions" (Gould, 1997). For example, the separation model states that cosmology is outside the domain of religion, and as such, the Bible has no grounds to teach us anything about the science of the cosmos. Adopting a separation approach, Ian Barbour states we should "read the opening chapters of Genesis as a symbolic portrayal of the basic relation of humanity and the world to God, a message about human creatureliness and the goodness of the natural order. These religious meanings can be separated from the ancient cosmology in which they were expressed" (Barbour, 1997: 85). Just as we wouldn't look to the weather channel for clues about how to work through a stormy relationship, we shouldn't read the book of Genesis for scientific facts about the planet.

But a simple fact remains—some scientists and some Christians make assertions that seem for all intents and purposes to conflict. As seen in the opening chapter, Richard Dawkins claims that religion is a science: "[Y]ou can't escape the scientific implications of religion. A universe with a God would look quite different from a universe without one. A physics, a biology where there is a God is bound to look different. So the most basic claims of religion *are* scientific. Religion *is* a scientific theory" (Dawkins, 1994). While Dawkins' claim is exaggerated, it is difficult to maintain that religious beliefs could never, in principle, conflict with scientific beliefs. Perhaps religion is mostly about sin and salvation, but it has also made claims that constitute an incursion into territory claimed by science. We may need to look further for a completely adequate account of the relationship between religion and science.

Integration

On the integration model, science and religion both contribute to the formation of a consistent set of beliefs. Unlike the separation model, the integration model encourages mutual interaction between science and religion. And unlike the conflict model, the integration model encourages a healthy give and take between science and religion. Why consider the integration model?

It's easy to see that religion, on various points, could and should seek and find guidance from science. For example, ancient religious accounts of creation are likely to be long on myth and short on math. Religious conceptions of the human person might stand some insights from psychology and neuroscience. While we all know that the earth revolves around the sun, the authors of most sacred texts did not. Science provokes religious thinkers to do some much-needed rethinking. For example, how should science aid the interpretation of a sacred text (almost certainly written in a prescientific, preliterate, age)?

But what about the other direction? Does religion have anything to offer science? The most common answer is that theology provides a worldview in which the assumptions of science, the subjective values discussed in the preceding sections, find their home. Scientists make crucial assumptions, assumptions that science itself is incapable of justifying. For example, scientists assume that our senses and reasoning processes are reliable and that they can assist in our quest to understand the world. Since science *starts* with the reliability of our senses and intellect, it cannot prove or justify their reliability. But if God created us in his image, as knowers, we have good reason to trust the reliability of our cognitive faculties. Scientists also assume the uniformity of nature—that the universe is the same everywhere and at all times. The uniformity of nature, like the reliability of our cognitive faculties, is quite at home within a religious worldview.

Religion may legitimately advise and caution science as well. Scientists have made claims that dramatically exceed their evidential base, often moving from physics or psychology into metaphysics or ethics. Behavioral psychologist B. F. Skinner, for example, articulated a quasi-scientific view of human psychology that left no room for moral responsibility or human dignity (Skinner, 1971). Religious believers, with a strong commitment to human responsibility and dignity, rightly objected to Skinner's excessive claims.

Some scientists clothe antitheistic diatribe in scientific garb. For example, Stephen Hawking, perhaps the most famous living physicist, has recently argued that the Big Bang, properly understood, leaves no room for God as creator of the universe: "Spontaneous creation is the reason there is something rather than nothing, why the universe exists, why we exist." Hawking claims: "Because there is a law such as gravity, the universe can and will create itself from nothing" (2010: 180). Hawking offers a theological conclusion based on scientific jargon. Thus adorned, it is hard for nonscientists to know what to think. Religious believers should not be overawed when

a scientist, however lauded, proclaims the irrelevance of the creator. While the quantum theory of gravity may allow for the *possibility* of an infinite universe, it looks, for all intents and purposes, to be *actually* finite, to have a beginning in time. While it takes a certain courage to chastise Stephen Hawking, religious thinkers may need to respond to poorly established scientific theories that are contrary to deeply entrenched religious beliefs.

Finally, science may require the kind of moral guidance that religious believers can offer. Einstein's claim that science needs religion was partly based on his fear of nuclear warfare. Although his theories provided the theoretical basis for nuclear bombs, he fervently opposed their development and deployment. We can make bombs that kill hundreds of thousands of people and devastate a country, but should we? We might be able to clone humans, but should we? Science itself, in our contemporary understanding, is about *what is*; morality is about what *ought to be*. So science, properly speaking, has nothing to say about ethics. But, to twist Einstein's words a bit, science without ethics is blind.

Conclusion

The integration model suggests various ways that religion might incorporate well-established science into religion. It is also open to ways in which religion might be incorporated into a complete scientific worldview—by justifying the foundations or methodology of science, by courageously questioning brash and poorly established science, by warning science when it has exceeded its bounds, or by providing science with a moral conscience. Religion, of course, sometimes intrudes improperly into well-established science. We are all aware of the ignorant theist demanding his day (sometimes in court) in the face of well-established science. Various debates in evolution and creation are cases in point. Let's reserve judgment about these matters until we've studied them in detail in the chapters that follow.