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GOD & THE BIG BANG

2ND EDITION

Discovering Harmony between Science & Spirituality

Daniel C. Matt

For People of All Faiths, All Backgrounds

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Contents

Part One

THE BIG BANG

1. In the Beginning

In the beginning was the big bang, fourteen billion years ago. The primordial vacuum was devoid of matter, but not really empty. Rather, it was in a state of minimum energy, pregnant with potential, teeming with virtual particles. Through a quantum fluctuation, a sort of bubble, in this vacuum, there emerged a hot, dense seed, much smaller than a proton, yet containing all the mass and energy of our universe. In far less than a trillionth of a second, this seed cooled and expanded wildly, faster than the speed of light, inflating into the size of a grapefruit.

During this inflation, the potential mass and energy could not yet manifest as particles; space was expanding too fast for any particles to congeal out of the vacuum. But as the expansion slowed down, energy latent in the vacuum precipitated as particles and antiparticles. These annihilated each other, except

for one in a billion particles, which survived to become the building blocks of matter. The annihilation gave birth to a flood of energy, generating the radiation of the big bang. The ball of the universe continued expanding—and has never stopped.

In its first few seconds, our universe was an undifferentiated soup of matter and radiation. It took a few minutes for things to cool down enough for protons and neutrons to form into the simple nuclei of heavy hydrogen and helium. But it was still far too hot for entire, stable atoms to hold together. Within about ten minutes, the production of nuclei stopped.

For the next several hundred thousand years, the universe was somewhat like the interior of a star, filled with subatomic particles and photons (radiant particles of energy). In this early eon, the photons occupied a range of the electromagnetic spectrum beyond what the human eye can see. The radiation was so turbulent and energetic that electrons could not stick to nuclei to form full-fledged atoms. As soon as an atom began to form, it was immediately ripped apart by radiation. Frenzied photons collided with free electrons, traveling only an infinitesimal distance before the next collision absorbed or scattered them. Since no photon could escape, the mixture of radiation and particles was essentially opaque, like a thick, impenetrable fog.

As the universe continued expanding, its temperature and energy gradually fell. After 400,000 years of cooling, when the temperature reached 3,000° Kelvin (4,940° F), a transition occurred. Having lost a critical amount of energy, the photons could no longer tear away electrons from circling around nuclei. Relieved of the photons' constant harassment, the electrons were now free for the first time to settle into orbit around the nuclei, forming stable atoms of hydrogen and helium, which, millions of years later, would grow into stars. Meanwhile, with unattached

electrons no longer available, the photons were also freed, able to travel great distances without colliding with an electron and being scattered or absorbed. The photons broke away from the building blocks of matter and became visible, flying through space in all directions. Matter and radiation had decoupled, and the universe turned transparent. This is the moment of "Let there be light!," *Yehi or*.

THE ECHO OF THE BIG BANG

Ever since, for fourteen billion years, radiation has pervaded space. As the universe expanded and cooled, the radiation's frequency continued decreasing, below the visible and infrared ranges, and into the microwave region. This cosmic background radiation is the residual heat signature of the big bang—its faint, persistent echo.

In the late 1940s, the physicists Ralph Alpher and Robert Herman theorized that this echo was still circulating through the universe. But it was not until 1964 that it was discovered—by accident, serendipitously—in New Jersey.

Two radio astronomers, Arno Penzias and Robert Wilson, were scanning the heavens with a new twenty-foot horn-shaped reflector antenna at Bell Telephone Laboratories in Holmdel, New Jersey. Wherever they turned the antenna, they picked up a mysterious background hiss. They first attributed this to electrical static caused by contaminants inside the horn antenna—maybe accumulated pigeon droppings. They dismantled and cleaned the throat of the antenna, but the static persisted. Meanwhile, in Princeton, about twenty-five miles west of Holmdel, the physicist Robert Dicke and his colleagues were designing an experiment to detect the cosmic residue of the big bang. Penzias

heard about the Princeton work and contacted Dicke. Upon hearing of Penzias's and Wilson's discovery, Dicke turned to his colleagues and said, "Well, boys, we've been scooped!" The puzzling hiss was indeed the cosmic background radiation, the echo of the big bang. Its temperature was close to what Alpher and Herman had predicted years earlier, about three degrees (Kelvin) above absolute zero.

The cosmic background radiation offers us an image of the universe 400,000 years after the big bang, the last time radiation interacted with matter. In 1989, the Cosmic Background Explorer satellite (COBE) was launched to analyze the structure of the background radiation in microscopic detail. Three years later, the COBE team announced that they had detected slight variations in the temperature of the radiation—the imprints of ancient ripples in the fabric of spacetime. These variations, caused by slight differences in the density of the universe in different regions, reveal that matter was not uniformly distributed: here and there hydrogen and helium were already being tugged together by invisible "dark matter," beginning to assume a structure that would evolve into galaxies and stars. The large-scale structures in the universe today—the clusters of thousands of galaxies—illuminate these ancient ripples "like glitter tossed on invisible lines of glue." For eons, in areas of our universe that were slightly denser than average, gravitation had its effect, slowing down the expansion.

Imagine a galaxy beginning to form: First, dark matter and ordinary matter (hydrogen and helium) form a halo. Within this halo, the hydrogen and helium cool further, falling toward the center. Gradually growing in density, these glimmering clouds of gas form into stars. Within each star, more helium is formed by the fusion of hydrogen, generating energy and fueling the star. After the core of the star has been mostly converted into helium,

the star becomes a red giant and begins fusing helium into still heavier nuclei such as carbon, silicon, and oxygen, generating further energy.

If the star is of medium size (more massive than our sun), after eventually turning into a red giant it will blow off its outer layers to form a gas cloud called a planetary nebula. These nebulae scatter elements such as carbon, nitrogen, and oxygen into space.

If the star is originally massive enough (at least eight times as massive as our sun), it will eventually convert most of the material in its core into iron. Because iron has such a tightly bound nucleus, it becomes impossible to extract any energy from it by further nucleosynthesis. At this point, the massive star is doomed. The energy generated by fusion had supported the star's outer layers, countering the force of gravity; without this support, the star collapses. As the entire mass of the star plunges toward its core, a burst of energy rebounds from the center as a huge shock wave. The star explodes, in the violent process forging even heavier elements, such as copper and silver. These, along with the lighter elements from the exploding core, are spewed into space. (Other heavy elements, such as gold, platinum, and uranium, may be ejected from the merger of very compact stars known as neutron stars.) Over eons, these various elements recycle themselves into new solar systems. Our solar system is one example of this recycling, a mix of matter produced by cycles of stars forming and exploding. We, along with our planet and everything on it, are literally made of stardust.

STIRRING THE PRIMORDIAL SOUP

Ten billion years A.B.T. (after the beginning of time), in a spiral galaxy called the Milky Way, about two-thirds of the way out

from the galaxy's center, an immense cloud of gas and dust started to contract. (The gas consisted of hydrogen and helium; the dust, of interstellar particles such as carbon and silicon atoms.) As the cloud collapsed toward its center, its rate of spin increased. This is similar to the spinning speed of a figure skater increasing as she pulls her arms inward. The centrifugal force of the spin flattened the cloud into a disk. Counter to this outward thrust, the attraction of gravity pulled most of the matter to the central region, eventually forming the sun. Within the flattening disk, particles not drawn into the center were able to cluster and cool into chunks of material, which in turn collided to form planets. Attracted by the gravity of the sun, each planet eventually settled into an orbit around the solar center, although the early solar system likely had episodes of major rearrangments.

The planet we call Earth took shape and began cooling down about 4.5 billion years ago. By about a billion years later, various microorganisms had developed. Exactly how, no one knows. But we do know that Earth's early atmosphere was composed of hydrogen, water vapor, carbon dioxide, and simple gases such as ammonia and methane. In such a climate, organic compounds may have synthesized spontaneously. Scientists have replicated the Earth's infant atmosphere by blending molecules of its components and exposing the mixture to ultraviolet light (which was stronger when the Earth was young) and electric sparks, approximating the action of lightning. The result: Amino acids assembled themselves, along with other organic molecules. Or perhaps life drifted to Earth in the form of spores from another solar system in our galaxy.

However life began, all its forms share similar genetic codes and can be traced back to a common ancestor; all living beings are cousins. We humans like to think of ourselves

as the pinnacle of creation, and it is true that we are the most complicated things that we know of in the universe. We are composed of about ten trillion cells. The retina of the human eye alone contains three million cells, each connected to the brain by an individual wire in the cable of the optic nerve. Our brain contains 100 billion cells, linked by over 100 trillion synaptic connections. Yet, we are part of the evolutionary process, descended from single-cell organisms that lived 3.5 billion years ago. We have evolved through an intricate, unrepeatable combination of chance mutation and natural selection. Our species—*Homo sapiens*—developed in Africa, splitting away from the chimpanzee line about seven million years ago. We still share with the chimps 98 percent of our active genes. If you'll pardon the expression, we are an improved ape.

BEFORE THE BIG BANG

The big bang is a theory, not a fact. To cosmologists, it offers the most convincing explanation of the evolution of the universe, "the best approximation to truth that we currently possess." The scientific consensus is that the big bang theory is correct within its specific domain: the evolution of our universe from perhaps one-billionth of a second after its origins up to the present. Whatever happened before that first fraction of a second lies beyond the limits of the current theory. The term "big bang" suggests a definite beginning a finite time ago, but the theory does not extend that far. In that sense, the first line of this chapter is somewhat misleading. It would have been more accurate to say: "One-billionth of a second after 'the beginning' was the big bang," since the ultimate origin of the universe is still unfathomed.

Beginning in 1979, cosmologist Alan Guth hypothesized and then developed the idea of cosmic inflation. According to this revolutionary theory, for an infinitesimal fraction of a second after "the beginning," space expanded exponentially, perhaps by a factor of 10^{50}. Following this, the universe continued to expand, but much less rapidly. The newborn universe would have had only tiny variations in density caused by quantum fluctuations, but inflation would have enlarged these into the significant variations that existed after 400,000 years. These variations went on to seed the galaxies.

Over the past several decades, Guth's idea has come to dominate theoretical models of the early universe. One particular version of the inflation theory was formulated by Stanford cosmologist Andrei Linde, portraying a universe that reproduces itself continually, attaining immortality. To Linde, our universe is one of countless baby universes, or what he calls "bubbles." The initial conditions in each of these bubbles differ, and diverse kinds of elementary particles interact in unimagined ways. Perhaps different laws of physics apply in each. They may even contain a different number of dimensions of spacetime.

Not all the domains inflate into large bubbles. Those that do, like ours, dominate the volume of the universe and sprout other bubbles in a perpetual chain reaction. The entire universe is a tree of life, a cluster of bubbles attached to each other, growing exponentially in time. Each baby universe is born in what can be considered a big bang—or should we say a little bang?—a fluctuation of the vacuum followed by inflation. Each world begins somewhere in the past and ends somewhere in the future, but the evolution of the entire universe has no end. As to the beginning of the entire universe, Linde's theory allows for an initial bang, but does not require

it. Flirting with religious language, Linde suggests that God "created a universe that has been unceasingly producing different universes of all possible types." In the course of its evolution, the universe realizes all possibilities: "Our cosmic home grows, fluctuates and eternally reproduces itself in all possible forms, as if adjusting itself for all possible types of life it can support. The performance is still going on, and it will continue eternally. In different parts of the universe, different observers see its endless variations."

If this is correct, perhaps we should translate the opening words of Genesis not as "In *the* beginning ...," but "In *a* beginning, God created ..." In fact, this could represent a more literal rendering of the original Hebrew: *Be-Reshit*, "In a beginning."

But what happened *before* this beginning?

The first big bang theorist was an obscure Belgian priest and mathematician named Georges Lemaître. In 1931, he proposed that the eruption of "a primordial atom" had given birth to the universe. His theory assumed that the universe emerged out of an infinitely small point of space packed with infinitely dense matter—what physicists call a "singularity." At a singularity, gravity, too, is infinite. The image is mind-boggling, but its depiction of a primordial instant harmonizes with traditional religious belief regarding a definite beginning of the universe. In fact, the Catholic Church endorsed the big bang model in 1951, claiming it accorded with the Bible.

Scientists, meanwhile, sought to demonstrate accordance between the expansion of the universe from a singularity and Einstein's theory of relativity. In the 1970s, physicists Stephen Hawking and Roger Penrose succeeded in doing just that. Later, however, Hawking theorized that in the initial stages of the universe the singularity disappears.

In Hawking's universe, time and space together constitute a four-dimensional foam of spacetime, finite in size yet without boundary or edge. If this seems hard to visualize, don't worry: It's not hard, it's impossible. But start, Hawking suggests, by picturing the two-dimensional surface of the Earth. This surface is finite, but has no edge or boundary: Sail as far as you can, and you won't fall off. Now add a third dimension of space and then a fourth dimension: time. The resulting spacetime has no boundary, no singularity. So it is meaningless to speak about what happened at the boundary, and the notion of a beginning becomes irrelevant.

Let's return to Earth. Stand anywhere on the equator and head north. Eventually, after adding several layers of clothes, you find yourself at the North Pole. You can't go any further north; "north" loses its meaning. Similarly, in the very early universe, the dimension of time becomes harder and harder to define. What we call "time" had a beginning, but that does not mean spacetime has an edge, just as the surface of the Earth has no edge at the North Pole.

We can imagine time stretching back forever, even before the universe existed. But time is simply something that enables us to label events *in* the universe. It is a parameter. Where such a parameter begins is artificial; it doesn't correspond to the edge of reality. Time is defined only *within* the universe. Outside of spacetime, before the beginning of the universe, time has no meaning. Asking what happened before the universe began is like searching for a point one degree north of the North Pole: It's simply not defined. Instead of conceiving of the universe as being created or coming to an end, we should realize that it just *is*.

According to Hawking, time itself began at the moment of the big bang. In confining time within the universe, Hawking follows Philo of Alexandria (the first-century Hellenistic Jewish philosopher) and Saint Augustine (the fifth-century Church father). The former suggested that time began after creation, with the start of motion; the latter concluded that God created time: "What did God do before He made heaven and earth? I do not answer as one did merrily: 'He was preparing hell for those who ask such questions.' For at no time had God not made anything because time itself was made by God."

Philo and Augustine believed in a God who creates the universe and inaugurates time. But for Hawking, the universe is completely self-contained, without boundary or edge and with no external first cause. "What place, then," he asks, "for a creator?"

Science has no consensus on the ultimate origin. Some theories espouse a well-defined beginning; others, like Hawking's, do not. But both suggest a radically new reading of Genesis. If God spoke the world into being, the divine language is energy; the alphabet, elementary particles; God's grammar, the laws of nature. Many scientists have sensed a spiritual dimension in the search for these laws. For Einstein, discerning the laws of nature was a way to discover how God thinks.

But does the universe have a purpose? Is there meaning to our existence? Why should we live ethically? Here, cosmology cannot help us very much. Darwin intensifies our problem. Are we different from other animals? Can we transcend violence and savagery? As the wife of an Anglican bishop remarked, upon hearing of Darwin's theory: "Descended from apes! My dear, let us hope that it is not true; but if it is, let us pray that

it will not become generally known." Her comment echoes the fear that knowing the true nature of our ancestors threatens to unravel the social fabric.

MYTH AND MEANING IN OUR LIVES

We have lost our myth. A myth is a story, imagined or true, that helps us make our experience comprehensible by offering a construction of reality. It is a powerful narrative that wrests order from chaos. We are not content to see events as unconnected, as inexplicable. We crave to understand some underlying order in the world. A myth tells us why things are the way they are and where they came from. Such an account is not only comfortable, assuring, and socially useful; it is essential. Without a myth, there is no meaning or purpose to life. Myths do more than explain. They guide mental processes, conditioning how we think, even how we perceive. Myths come to life by serving as models for human behavior. On Friday evening, as our family begins Shabbat, I sometimes imagine God, having created the world in one very packed week, finally taking a break. "God rested and was refreshed," *Shavat va-yinnafash*. This mythical image enables me to pause, to slow down and appreciate creation. By observing Shabbat, I am imitating the divine. Order reemerges out of the impending chaos of life.

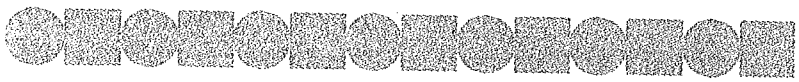
But what do we do when the myths of tradition have been undone, when the God of the Bible seems so unbelievable? Is there really someone "up there" in control, charting the course of history, reaching down to rescue those in need, tallying up our good and bad deeds for reward and punishment? Many people have shed the security of traditional belief; they are more likely to experience a gaping, aching void than the satisfying

fullness of God's presence. If they believe in anything, perhaps it's science and technology. And what does science provide in exchange for this belief? Progress in every field except for one: the ultimate meaning of life. Some scientists insist that there is no meaning. As one leading physicist has written, "The more we know about the universe, the more it is evident that it is pointless and meaningless."

Science is not the only challenge to believing in God. Human suffering also corrodes faith, leaving us suspended and alone. As Job's suffering led him to question whether God is just, the Holocaust has led many to wonder whether God is dead. But to say "God is dead" is really to make a statement about human beings: It means that the traditional way of conceiving of God no longer works. For after Auschwitz, how can we speak of a caring, compassionate, personal God?

Through the lens of belief, Christians, Muslims, and Jews have gazed at their own history, searching for traces of a divine plan. The Jewish people, in particular, have interpreted their historical traumas as divine punishment. By helping them cope with an imperiled existence, this strategy enabled them to salvage sense from suffering. Biblical prophets linked the destruction of Solomon's Temple to the people's moral failings. Yohanan ben Zakkai, one of the founders of rabbinic Judaism, similarly explained the fall of the Second Temple. The liturgy for the three Jewish pilgrimage festivals includes the lament: "On account of our sins, we were exiled from our country and banished far from our land; so we cannot go make pilgrimage to worship You." Some still invoke this principle to explain the Holocaust. The sixth Lubavitcher *rebbe*, Joseph Isaac Schneerson, for instance, explained that Hitler was God's instrument for chastising the Jews, who had abandoned the ways of Torah. This

notion is at once traditional and obscene. Its vulgar Christian analogue—officially repudiated, but still encountered—is: "The Christ-killers got what was coming to them." Most Jews and Christians recoil from such interpretations of the Holocaust. But there are only two alternatives: Either God does not exist—or She is very different than we have thought.



Part Two

GOD, SELF, AND COSMOS

As for his intention in coining the name, Hoyle later explained in an interview: "The BBC was all radio in those days, and on radio, you have no visual aids, so it's essential to arrest the attention of the listener and to hold his comprehension by choosing striking words. There was no way in which I coined the phrase to be derogatory; I coined it to be striking, so that people would know the difference between the steady state model and the big bang model." See Ken Croswell, *The Alchemy of the Heavens*, 113–14.

Two decades earlier, in 1928, the astronomer and physicist Arthur Eddington had written: "As a scientist I simply do not believe that the present order of things started off with a bang." He later wrote, "Philosophically the notion of an abrupt beginning of the present order of Nature is repugnant to me." See Arthur S. Eddington, *The Nature of the Physical World*, 85; idem, *New Pathways in Science*, 59.

See also Hoyle, *The Nature of the Universe*, 119; idem, *Home Is Where the Wind Blows*, 253–55; idem, as quoted by Alan Lightman and Roberta Brawer, *Origins*, 60; Simon Singh, *Big Bang*, 351–53; Simon Mitton, *Fred Hoyle*, 127–29.

he held a different theory ... According to Hoyle's steady state theory, the universe has been expanding forever without changing its overall appearance, as matter emerges in a process of continuous creation. See Hoyle, *Home Is Where the Wind Blows*, 399–423.

The origin of the cosmos has such grandeur ... Richard Elliott Friedman, *The Disappearance of God*, 264.

"Spacetime tells matter..." See John Archibald Wheeler, *Geons, Black Holes, and Quantum Foam*, 235. Cf. idem, *A Journey into Gravity and Spacetime*, 12: "If spacetime grips matter, telling it how to move, then it is not surprising to discover that matter grips spacetime, telling it how to curve." See also Charles W. Misner, Kip S. Thorne, and John Archibald Wheeler, *Gravitation*, 5.

the infinite God has withdrawn Itself I utilize various pronouns in referring to God in this book. When quoting traditional sources or referring to the traditional conception of God, I often use "He." When referring or alluding to the kabbalistic terms *Shekhinah* (the feminine divine presence) or *Binah* (the Divine Mother), I use "She." When referring to *Ein Sof*, the infinite reality of God beyond categories of gender, I use "It."

the Local Group ... Timothy Ferris, *Coming of Age in the Milky Way*, 175.

Chapter 1

The primordial vacuum ... teeming with virtual particles ... Ferris, *Coming of Age in the Milky Way*, 351–61.

an undifferentiated soup of matter and radiation Steven Weinberg, *The First Three Minutes*, 102.

Kelvin The Kelvin scale begins at absolute zero, the temperature at which molecular energy is at a minimum. This corresponds to a temperature of –273.15° Celsius (or Centigrade). A Kelvin degree is the same size as a Celsius degree.

the universe turned transparent ... "Let there be light!" See Ferris, *Coming of Age in the Milky Way*, 343; Weinberg, *The First Three Minutes*, 7–8; Gerald L. Schroeder, *Genesis and the Big Bang*, 88–90. For a critique of Schroeder's attempt to fit scientific cosmology into the biblical framework of creation, see Friedman, *The Disappearance of God*, 230–34.

"Well, boys, we've been scooped!" Michael D. Lemonick, *Echo of the Big Bang*, 43.

ripples in the fabric of spacetime ... See George Smoot and Keay Davidson, *Wrinkles in Time*, 285; John Gribbin, *In the Beginning*, 37; Joel R. Primack and Nancy E. Abrams, "'In a Beginning ...': Quantum Cosmology and Kabbalah," 68; Friedman, *The Disappearance of God*, 223–27.

We ... are literally made of stardust Technically, stardust makes up about 90 percent of a human body's weight (consisting mostly of oxygen and carbon, along with small amounts of nitrogen, calcium, and phosphorous, and tiny amounts of numerous other elements). About 10 percent of our weight is constituted by hydrogen, all of which originated in the big bang and its aftermath, long before any stars were formed. See Primack and Abrams, *The View from the Center of the Universe*, 89; 324, n. 1.

chunks of material ... collided to form planets Ferris, *Coming of Age in the Milky Way*, 167.

"the best approximation ..." Barrow and Silk, *The Left Hand of Creation*, 21.

beyond the limits of the current theory See Willem B. Drees, *Beyond the Big Bang*; Hubert Reeves, "Birth of the Myth of the Birth of the Universe."

Alan Guth... developed the idea of cosmic inflation... See Alan H. Guth, *The Inflationary Universe*; Singh, *Big Bang*, 477–79. The concept of inflation was first proposed by Guth to solve the problem of magnetic monopoles. He soon realized that the theory also solves two other cosmological difficulties: the "flatness problem" and the "horizon problem." Later it became clear that inflation also explains the variations in density. See Guth, *The Inflationary Universe*, 147–87, 213–43.

Andre Linde ... See Andrei Linde, "The Self–Reproducing Inflationary Universe," 48–55.

a different number of dimensions of spacetime Andre Linde, "Particle Physics and Inflationary Cosmology," 68. Spacetime is usually conceived of as a four-dimensional fabric combining the three dimensions of space and the dimension of time. Each event in the universe represents one point in spacetime.

God "created a universe ..." Andre Linde, "Inflation and Quantum Cosmology," 607.

"Our cosmic home grows ..." Linde, "The Self-Reproducing Inflationary Universe," 55; idem, "Particle Physics and Inflationary Cosmology," 68.

"In a beginning" Primack and Abrams, "'In a Beginning ...'", 71; idem, *The View from the Center of the Universe*, 7.

The Catholic Church endorsed the big bang ... Stephen W. Hawking, *A Brief History of Time*, 49; Singh, *Big Bang*, 360–62.

the singularity disappears See Hawking, *A Brief History of Time*, 137–46.

the dimension of time becomes harder and harder to define Stephen W. Hawking, "The Edge of Spacetime," 14; see Drees, *Beyond the Big Bang*, 55.

Outside of spacetime ... time has no meaning Stephen W. Hawking, "Quantum Cosmology," 651; idem, *A Brief History of Time*, 8.

time itself began at the moment of the big bang Hawking, "Quantum Cosmology," 650; idem, *A Brief History of Time*, 49; Drees, *Beyond the Big Bang*, 55.

"What did God do ..." Augustine, *Confessions*, 11.

"What place, then ...?" Hawking, *A Brief History of Time*, 146; see Paul Davies, *The Mind of God*, 72–73.

God's grammar, the laws of nature See Don Page, in *Origins*, edited by Lightman and Brawer, 409.

For Einstein ... See Norbert M. Samuelson, *Judaism and the Doctrine of Creation*, 237. Samuelson indicates that Einstein's view accords with classical Jewish philosophy.

"Descended from apes!..." Carl Sagan and Ann Druyan, *Shadows of Forgotten Ancestors*, 276.

Shavat va-yinnafash Exodus 31:17.

"The more we know ..." Steven Weinberg, cited in Heinz Pagels, *Perfect Symmetry*, 363–64. Weinberg makes a similar statement at the end of *The First Three Minutes*, 154; see his discussion of the reactions to this statement in *Dreams of a Final Theory*, 255–56. For a wide range of responses to Weinberg from some two dozen leading cosmologists, see Lightman and Brawer, *Origins*, passim.

"God is dead" See Richard L. Rubenstein, *After Auschwitz*. As Eugene Borowitz has pointed out (*Renewing the Covenant*, 36, 41), the traditional God whose death was described by Rubenstein had already been radically reconceived by many Jews.

Yohanan ben Zakkai ... Babylonian Talmud, *Ketubbot* 66b.

to explain the Holocaust ... Rubenstein, *After Auschwitz*, 11, 16, 160. Justin Martyr, the second-century Church father, explained the destruction of the Second Temple as God's punishment of the Jews for the sin of not accepting Christ. See his *Dialogue with Trypho*, 202.

Chapter 2

a contemporary physicist ... Harald Fritzsch, *The Creation of Matter*, 276.

"When you have listened ..." Heraclitus of Ephesus, Fragment 50, in Kathleen Freeman, *Ancilla to the Pre-Socratic Philosophers*, 28. *Logos* means "word" and denotes the rational principle that develops and governs the cosmos.