RETURN
of the
GOD HYPOTHESIS

THREE SCIENTIFIC DISCOVERIES THAT REVEAL THE MIND BEHIND THE UNIVERSE

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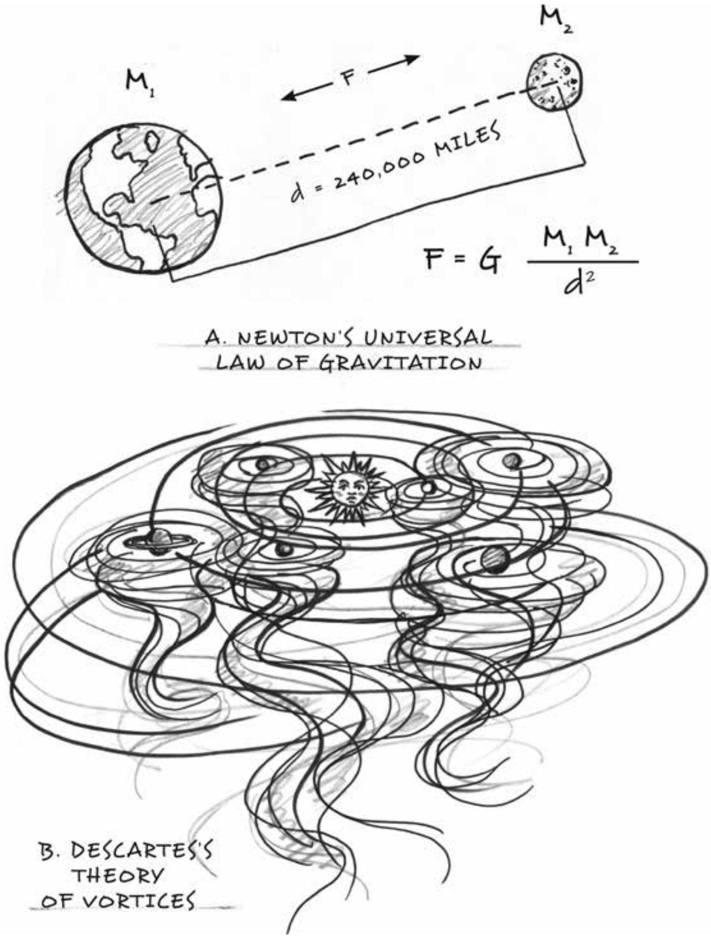


FIGURE 2.5

Comparison of Newton's and Descartes's view of gravitational attraction.

TOP: Newton's universal law of gravity states that massive bodies exert a force on each other that is proportional to the product of their masses and inversely proportional to the square of the distance between them. It envisioned action at a distance or force being transmitted through empty space.

BOTTOM: Descartes's theory of vortices postulated that space was filled entirely by an invisible material substance known as ether. As the ether whirled around the sun, it pushed the planetary bodies in orbit around it.

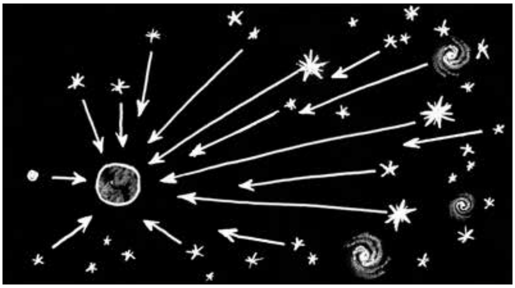


FIGURE 4.1A

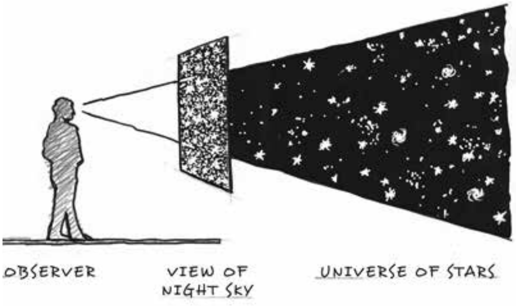


FIGURE 4.1B

Olbers's Paradox. The light from stars in the night sky at all distances appears to fill different parts of our visual field. If the universe were infinitely large, and stars or galaxies were distributed throughout it, every line of sight would terminate with a star or galaxy. In that case, the night sky would appear entirely illuminated and no dark regions would remain. That the night sky does not appear entirely white suggests that the universe is not infinitely large.

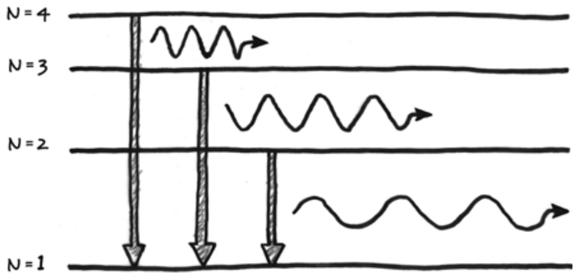


FIGURE 4.9

Spectral light emissions. When atoms gain energy from other atoms, electrons, or photons, they jump to higher energy levels. Such "excited" electrons then quickly drop down to lower energy levels, resulting in the emission of photons with energies equal to the differences between the energy levels. The energy of an emitted photon is directly proportional to its frequency and inversely proportional to its wavelength.

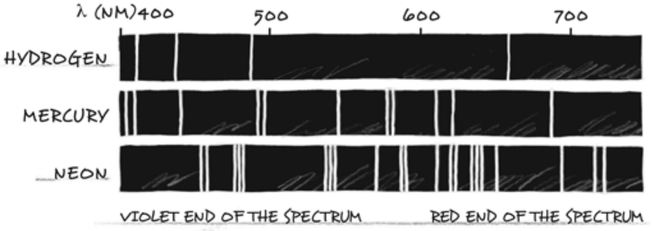


FIGURE 4.10
Different chemical elements emit a different combination of specific wavelengths of light in what is called an emission spectrum.

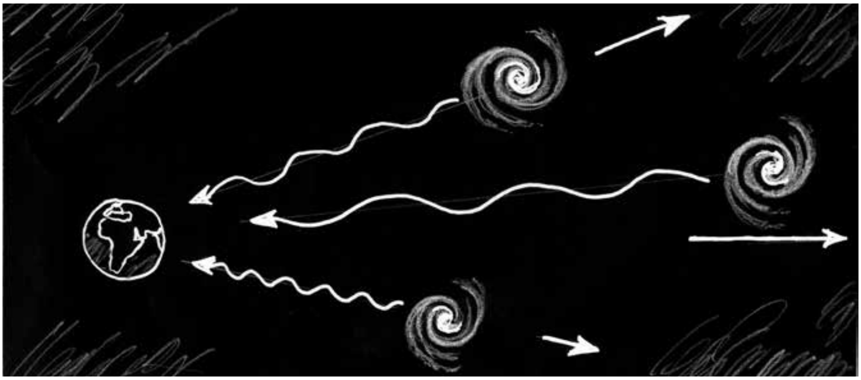


FIGURE 4.11A
Astronomers have discovered that distant galaxies are moving away from each other and from the earth. Consequently, light emitted at a given wavelength from distant stars will appear to be stretched out or "red shifted." Moreover, the farther galaxies are from the earth the faster they will recede from us and the more the wavelengths of light coming from them will be stretched out.

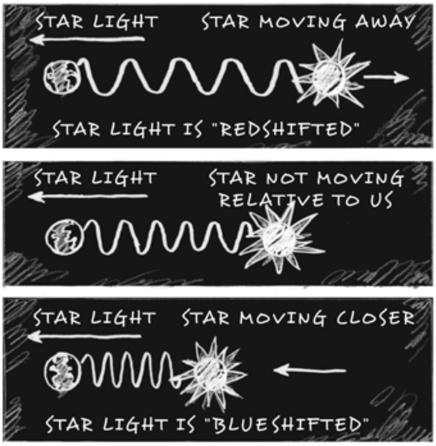


FIGURE 4.11B

The light coming from a galaxy moving away from the earth appears "red shifted" as the wavelengths of the light coming from that galaxy are stretched out or lengthened. The light coming from a galaxy moving toward the earth appears "blueshifted" as the wavelengths of the light coming from that galaxy are compressed or shortened.

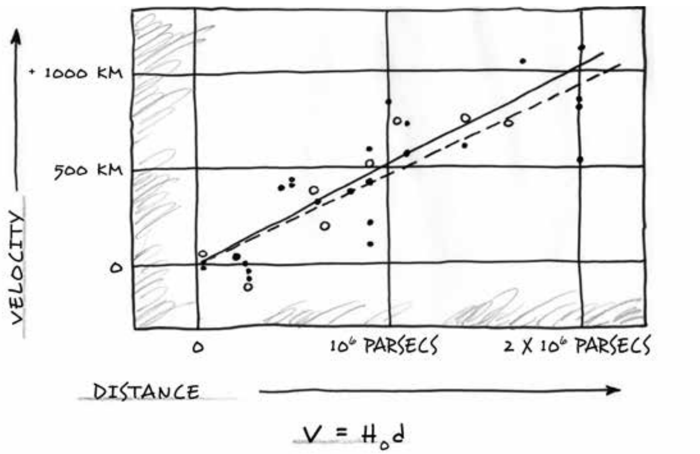


FIGURE 4.13

Galactic Recession and Hubble's Law. This chart shows the recessional velocity of several galaxies plotted against their distances from earth. It establishes that the farther galaxies are from earth, the faster they are receding from us. This linear relationship between recessional velocity and distance is known as Hubble's Law. (A parsec is a unit of distance used in astronomy.) See: Hubble, "A Relation Between Distance and Radial Velocity Among Extra-Galactic Nebula," 172.

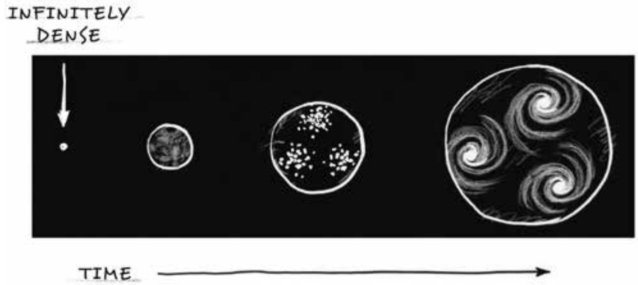


FIGURE 4.14

Expansion of the universe. The expansion of the universe after the big bang. Initially after the beginning of the universe, space was filled with a hot amorphous plasma. Then, about 380,000 years after the big bang, the plasma congealed into atoms. Later, gravitational attraction caused the atoms to coalesce into stars and galaxies.

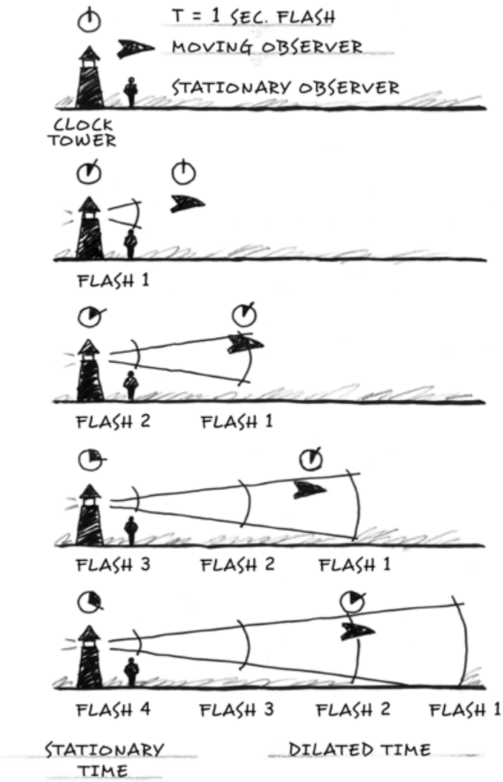


FIGURE 5.2

Time dilation. According to Einstein's theory of special relativity, time appears to slow down to an observer in a moving reference frame such as a spaceship as that moving object approaches the speed of light. This figure depicts the basis of Einstein's intuition by showing that as a spaceship moves away from a clocktower at high speed the information about the passage of time as conveyed by the moving hands on the clock (and successive flashes of light coming from the tower) will take longer to get to the spaceship than to a stationary observer closer to the tower. Thus, time near the clock will appear to move more slowly to the astronaut.

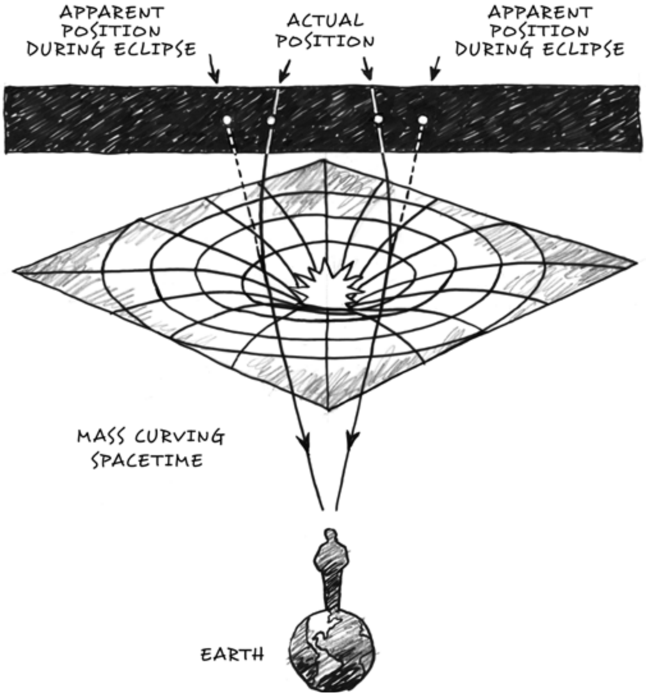
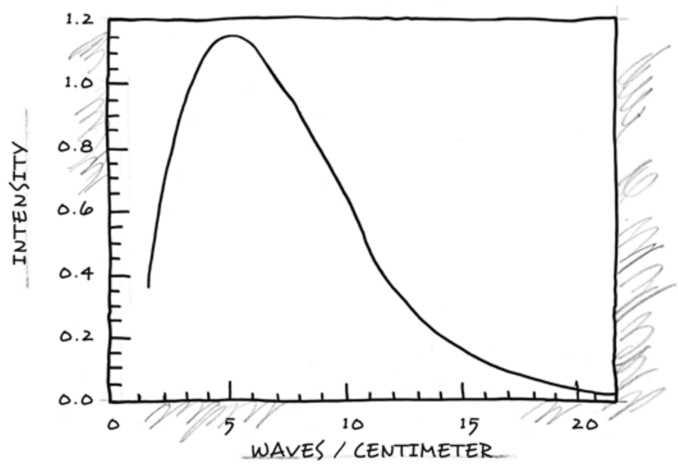


FIGURE 5.3

According to Einstein's theory of general relativity, massive bodies curve space. This curvature bends the path of light toward a massive body as it moves past. The diagram shows light coming from two distant stars passing through the gravitational field of the sun. The curvature of space around the solar mass alters the path, so the light curves around the sun. As a consequence, the apparent positions of the stars in the night sky appear to an earthbound observer to have shifted from their true position. Note how the stars' apparent positions in the diagram are shifted more to the left or more to the right of their actual positions. This effect is only observable on earth during a solar eclipse when the light coming from the sun is blocked by the moon. A famous experiment was performed in 1919 by Sir Arthur Eddington during a solar eclipse. He identified the predicted light-bending by observing the resulting shift in the apparent position of a particular star as the moon passed in front of the sun during the eclipse.

FIGURE 5.9

According to the steady-state model, the universe must maintain a constant density of matter. But, as the universe expands, the density of the universe (i.e., the amount of matter per unit of volume) would begin to decrease. Consequently, to maintain a constant density, matter must be continually created throughout the universe. In effect, the stretching of space causes new matter to pop into existence. This figure depicts how steady-state proponents envision both the expansion of space and the continual creation of matter and energy.



COSMIC MICROWAVE BACKGROUND RADIATION SPECTRUM

FIGURE 5.11

A perfectly opaque object in thermodynamic equilibrium, known as a "blackbody," exhibits a characteristic distribution of frequencies or wavelengths of radiation. This graph shows the distribution of wavelengths of the cosmic background radiation. It conforms beautifully to the curves characteristic of known blackbodies, suggesting that the cosmic background radiation issued from a relatively compact, opaque, early state of the universe.

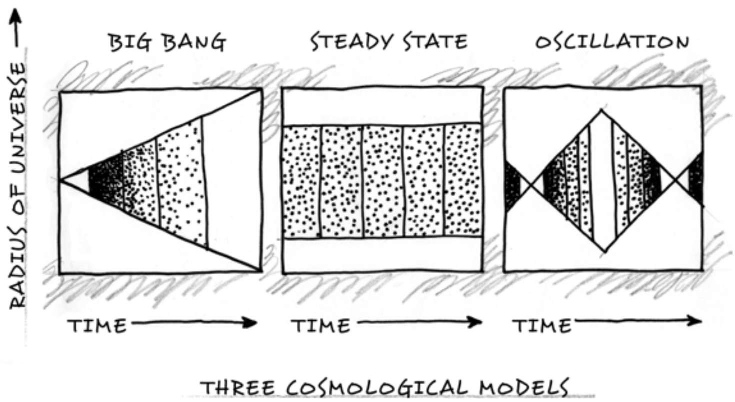


FIGURE 5.12

Three cosmological models: the big bang, steady state, and oscillating universe. The big bang model implies the universe had a beginning. The steady-state model implies that the universe has existed eternally and matter is being continuously created. The oscillating model depicts the universe expanding and collapsing an infinite number of times. All three models assume a presently expanding universe.

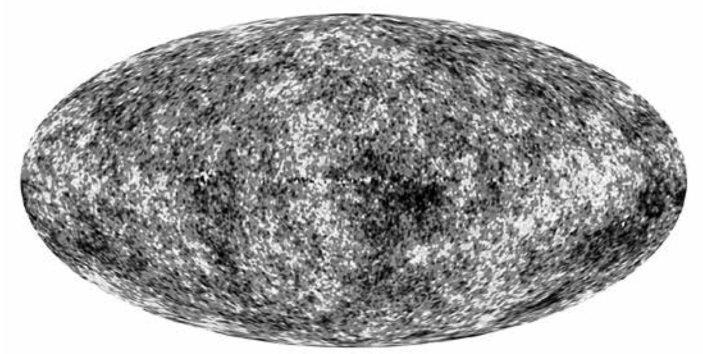


FIGURE 5.13

The big bang theory predicts the existence of a low-level cosmic background radiation. For the big bang to explain the origin of galaxies, there must have also been small variations in the intensity of this radiation from the earliest stages of the universe. As the Cosmic Background Explorer (COBE) satellite has scanned the night sky, it has detected these slight variations. This figure reproduces, in an enhanced black and white form, a famous color image of the night sky depicting these variations.

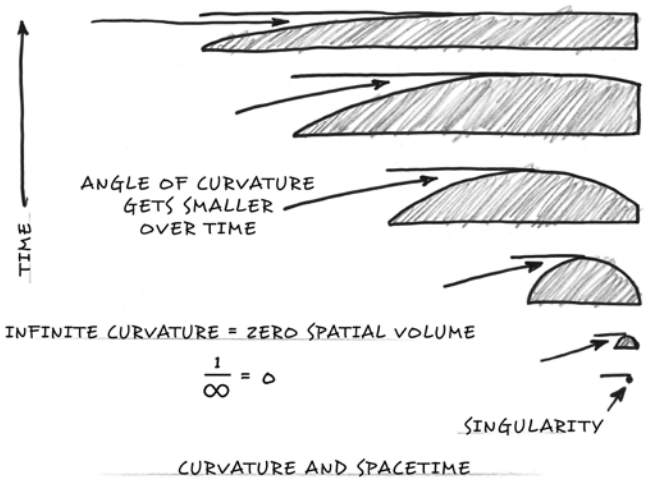


FIGURE 6.3

As the universe expands, space (or "spacetime") flattens and the curvature of space decreases and approaches zero. Curvature increases, however, in the reverse direction of time, eventually reaching a limit of infinite curvature. Infinite curvature corresponds to zero spatial volume, thus marking the beginning of the universe.

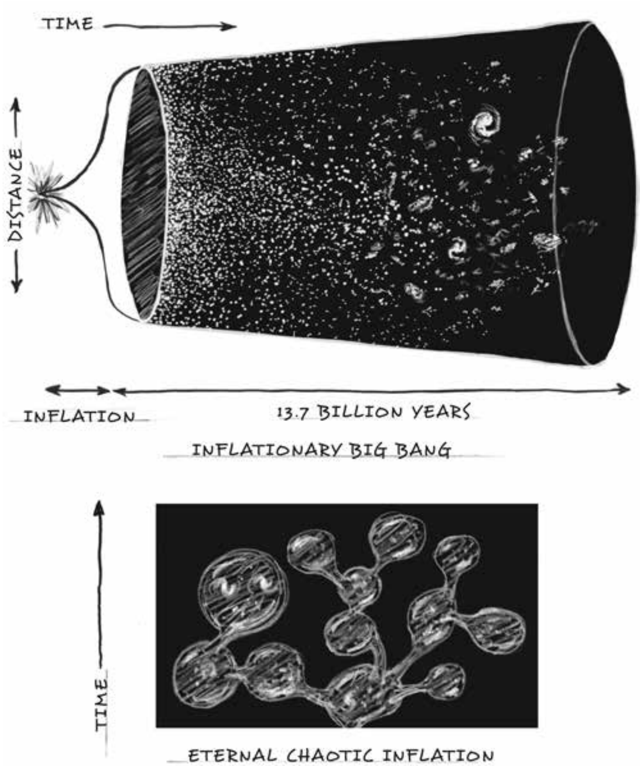


FIGURE 6.5

TOP: As first formulated, the inflationary cosmology model holds that the universe had a beginning, and it initially expanded extremely rapidly before slowing down to a more sedate pace of expansion.

BOTTOM: Later cosmologists formulated the eternal chaotic inflation model. According to this model, as the universe expands different regions of space will stop inflating, causing new bubble universes to emerge. This process would then continue indefinitely, producing an infinite number of "bubble universes" separated from each other by an inflating ocean of expanding space.

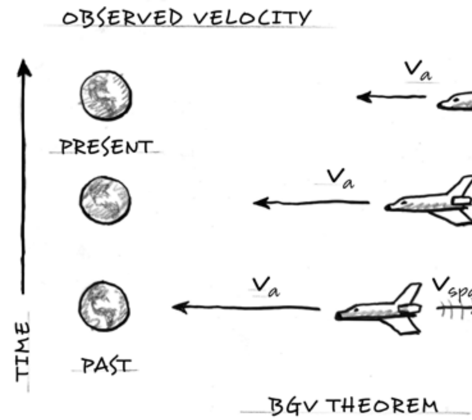


FIGURE 6.6

The BGV Theorem. The Borde-Guth-Vilenkin (BGV) theorem states that any universe that is on average expanding must have had a beginning. The theorem can be understood by imagining a spaceship traveling toward earth. The apparent velocity (V_a) for the spaceship as measured by an earthbound observer equals the actual velocity of the spaceship minus the velocity of the local space in which the spaceship resides as that space moves away from the earth due to the expansion of the universe. But what if we think about the apparent velocity of the spaceship in the past by back extrapolating in time? Since in the forward direction of time space is expanding and moving the spaceship farther from the earth (than it would otherwise be), if we extrapolate in the reverse direction of time, the spaceship would be closer to the earth (than it would otherwise be). The recessional velocity of space would have been smaller at that point in the past since recessional velocity increases with distance from the earth in an expanding universe but would have been slower in the past when the universe had not yet expanded as much. Consequently, V_a, the velocity of the spaceship relative to the earth, would be larger. Moving farther back in time still, the apparent velocity would increase again. With additional back extrapolations, the apparent velocity of the spaceship, V_a, would eventually equal the speed of light, which represents an absolute limit for the velocity of any object according to special relativity. At that point, no further back extrapolations in time would be possible (or physically meaningful), thus implying the universe and its expansion must have had a beginning.

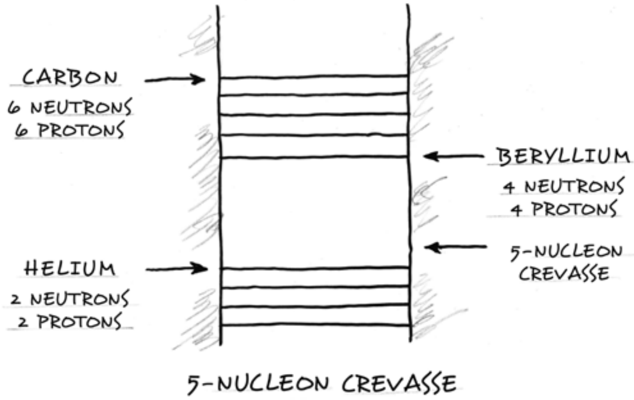


FIGURE 7.2

Astrophysicist Fred Hoyle initially thought that the most plausible pathway for building heavier elements (such as carbon) from lighter elements (such as hydrogen and helium) would occur as the result of incremental accretion of individual protons or neutrons (known collectively as "nucleons"). But Hoyle discovered that building elements heavier than helium in this manner required passing through atomic structures with five total protons and neutrons. Nuclear physicists know these five "nucleon" configurations to be unstable and call this barrier between lighter and heavier elements the "5-nucleon crevasse."

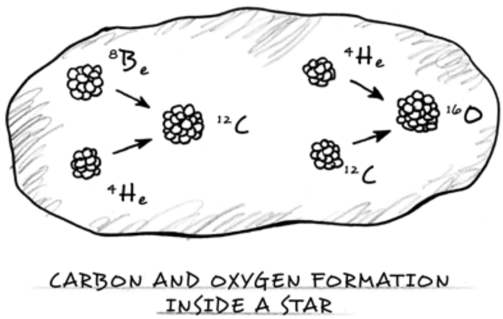


FIGURE 7.3

Carbon and oxygen formation inside a star. Astrophysicist Fred Hoyle realized that forming carbon from the simpler elements of beryllium and helium could only occur if a version of the carbon atom with a higher energy state (or "resonance") existed. That a carbon atom with such a precise resonance level does exist, implied a host of other prior finely tuned parameters in order for carbon formation to occur. Oxygen formation from carbon and helium also requires many prior finely tuned parameters.

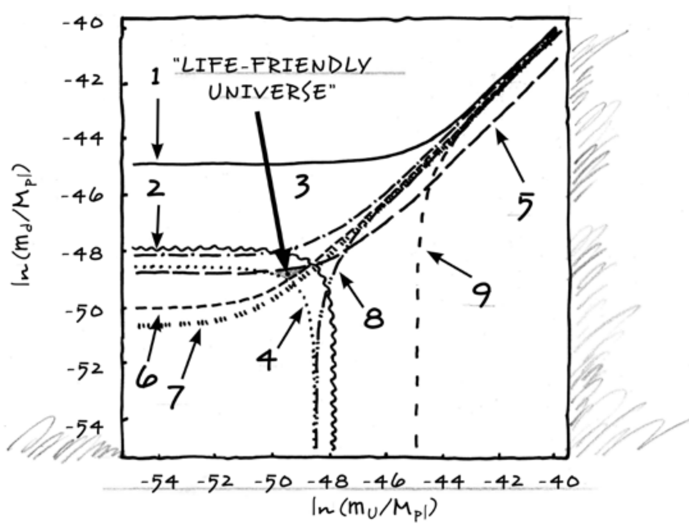


FIGURE 7.4

Each point on the graph corresponds to possible values for the masses of the up and down quarks (M_u, M_d). The masses are scaled by the Planck mass, M_{pl}, since Planck units are the most natural in cosmology. Each of the nine lines on the graph separates the regions corresponding to life-permitting and non-life-permitting universes for a specific criterion such as allowing for the existence of stable protons. In a universe capable of supporting life, all nine criteria must be met simultaneously, so the life-permitting region is the intersection of all nine life-permitting regions, marked in gray. That area corresponds to a miniscule proportion of all plausible values.

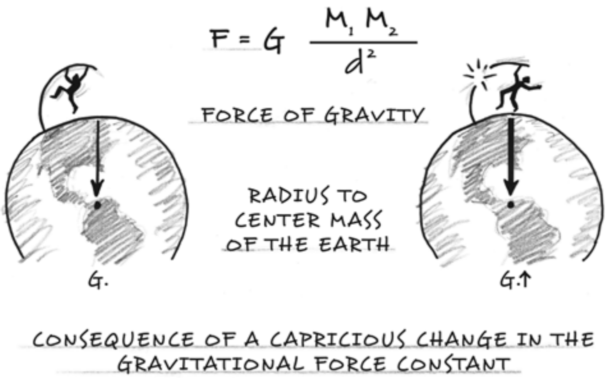


FIGURE 7.5

If the gravitational constant G were to increase dramatically during a pole vaulter's jump, the force of gravity exerted on the vaulter would increase proportionally, though the vaulter's mass, the earth's mass, and the distance from the center of earth (at that moment) would not have changed. Such a capricious change in the value of G could then result in the vaulter's pole snapping and the vaulter crashing to the earth.

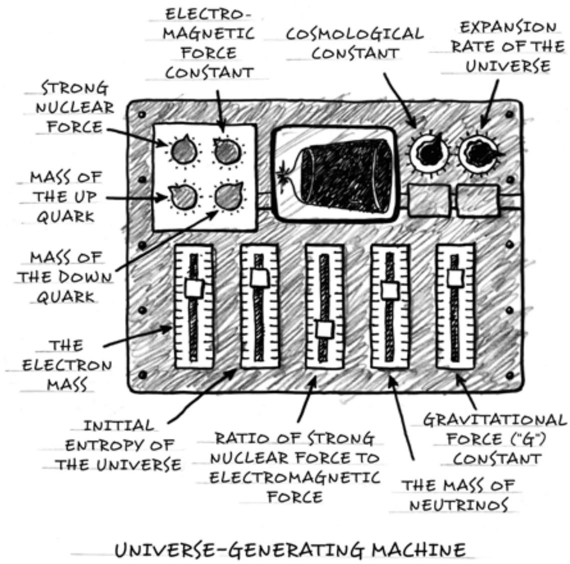


FIGURE 7.8

A hypothetical universe-generating machine illustrating the fine tuning of the laws and constants of physics and the initial conditions of the universe.

FIGURE 8.1

When creating a tunnel, the precise angle and force of dynamite charges will determine the outcome. In the same way, the initial configuration of matter and energy at the beginning of the universe will determine whether or not a life-permitting universe will result.

FIGURE 8.4

Specified complexity or functional information as an indicator or "signature" of intelligence. The inner harbor of Victoria, Canada houses flower beds that spell out the phrase "Welcome to Victoria." The arrangement of flowers conveys "specified" or functional information, an unmistakable sign of intelligence. No one, for example, would attribute this pattern of flowers to an undirected process such as birds flying over the harbor randomly dropping seeds.

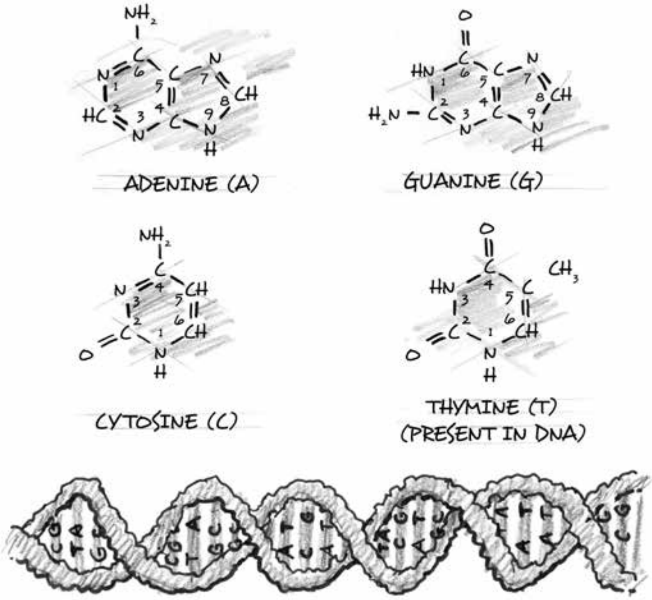


FIGURE 9.2

Francis Crick's sequence hypothesis. According to the sequence hypothesis, the four nucleotide bases of adenine, guanine, cytosine, and thymine function like alphabetic characters in a written text or digital characters in a section of machine code. In particular, their precise arrangement provides the instructions for building the proteins and protein machines that cells need to stay alive. The chemical formulas of these four bases are depicted at the top of the figure. Underneath them, a twisting DNA helix shows a series of these nucleotide bases (i.e., "genetic letters") conveying genetic assembly instructions.

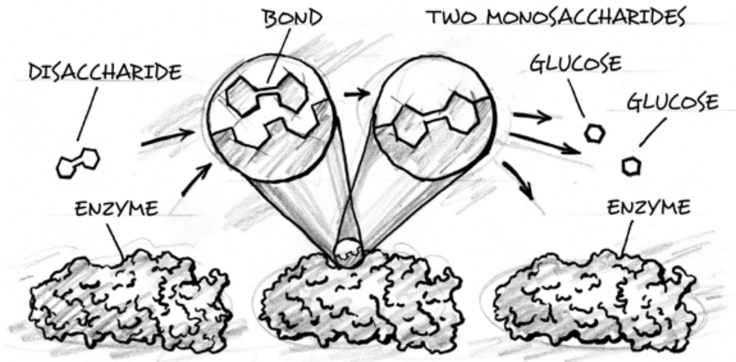


FIGURE 9.3

The three-dimensional specificity of proteins. The instructions in DNA direct the production of functional proteins, including enzymes. This diagram shows an enzyme breaking apart a two-part sugar molecule (a disaccharide). Notice the tight three-dimensional specificity of fit between the enzyme and the disaccharide at the active site where the reaction takes place.

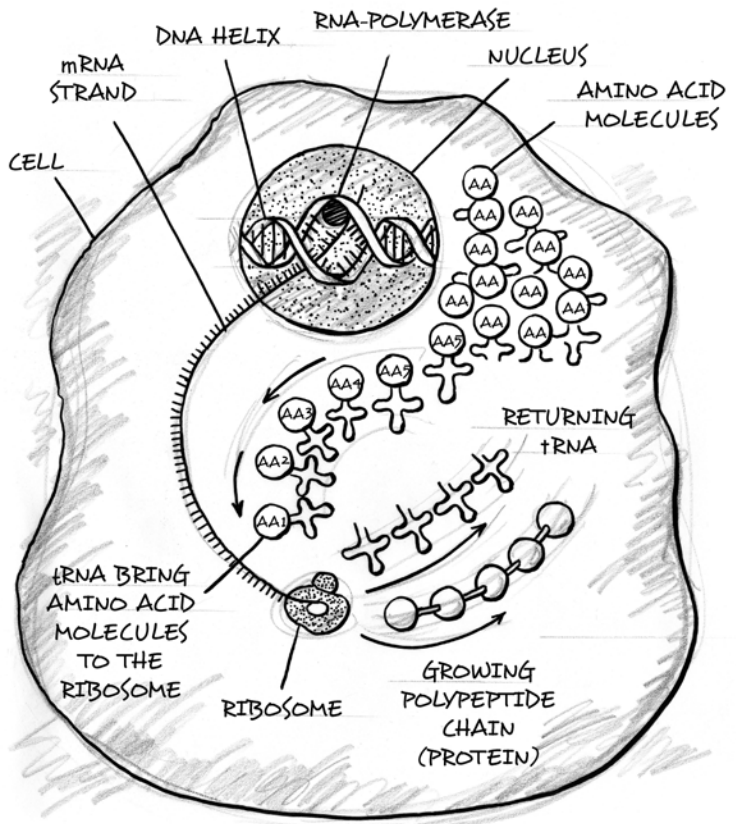


FIGURE 9.4

A simplified schematic of gene expression showing the process by which genetic information stored in DNA directs the production of proteins in the cell.

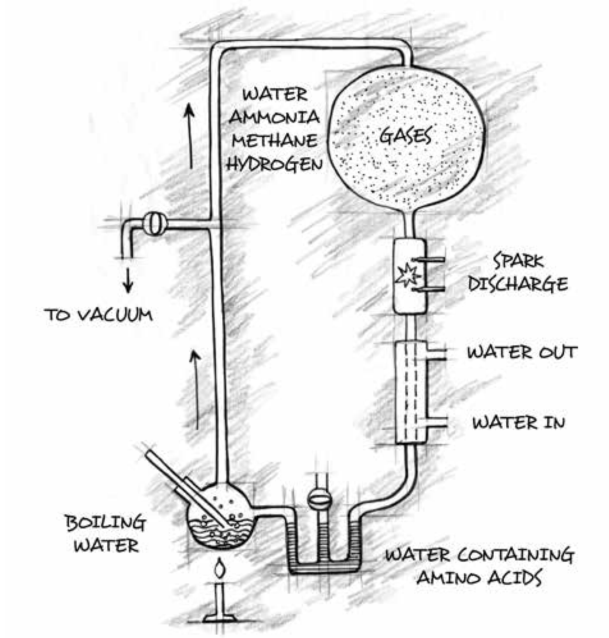


FIGURE 9.5

The Miller-Urey experiment simulating the production of amino acids from a mixture of gases that allegedly matched the prebiotic atmosphere.

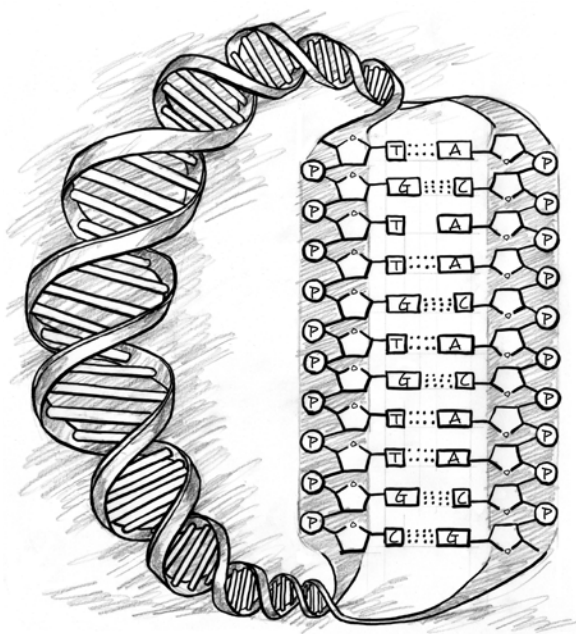


FIGURE 9.7

Model of the chemical structure of the DNA molecule depicting the main chemical bonds between its constituent molecules. Note that no chemical bonds link bases (designated by the letters in boxes) in the longitudinal message-bearing axis of the molecule. Note also that the same kind of chemical bonds link the different nucleotide bases to the sugar-phosphate backbone of the molecule (denoted by pentagons and circles). These two features of the molecule ensure that any nucleotide base can attach to the backbone at any site with equal ease, thus showing that the bonding properties of the chemical constituents of DNA do not determine its base sequences.

FIGURE 9.8

The concepts of order, complexity, and specified complexity are illustrated above. This figure shows three qualitatively different types of sequences as defined by the information sciences. Note that DNA contains sequences that exhibit specified complexity, not simple redundant order.

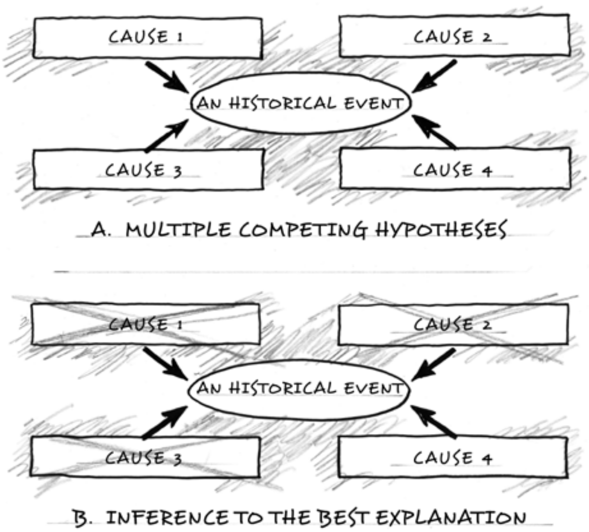


FIGURE 9.11

In the method of multiple competing hypotheses, or inference to the best explanation, scientists posit multiple possible hypotheses and then elect that hypothesis which, if true, would best explain the event or evidence in question. Historical scientists have identified causal adequacy as a key criterion for determining which hypothesis or explanation qualifies as the best. The above figure depicts a process of reasoning in which historical scientists have proposed four potential causal explanations, eliminated three from consideration, and elected a fourth. In the diagram, this fourth causal hypothesis would presumably represent a cause known to be sufficient to produce the event in question—in other words, a causally adequate hypothesis.

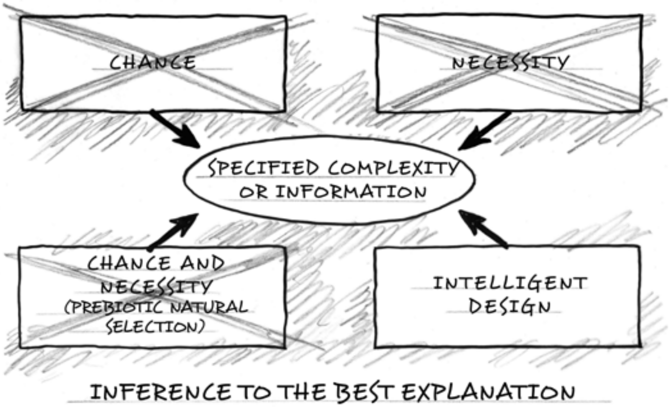


FIGURE 9.12

In *Signature in the Cell* and in this chapter, I infer intelligent agency or design as the best, most causally adequate explanation for the origin of the functional information or specified complexity necessary to produce the first living cell.

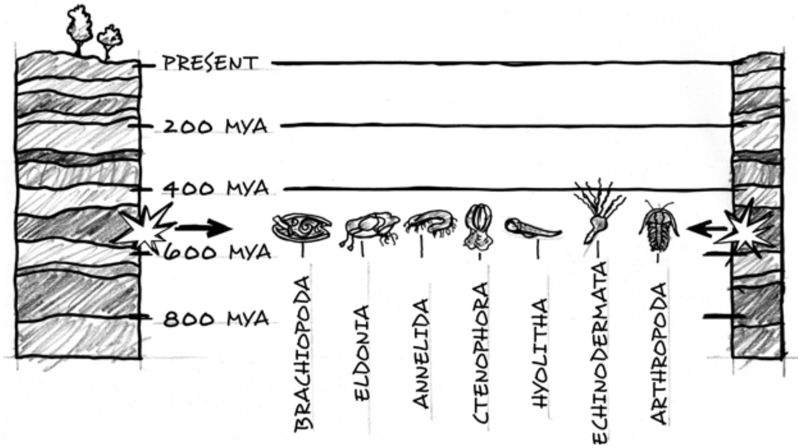


FIGURE 10.1

Representatives of some of the major animal groups that first appear abruptly in the sedimentary rock record during the Cambrian period.

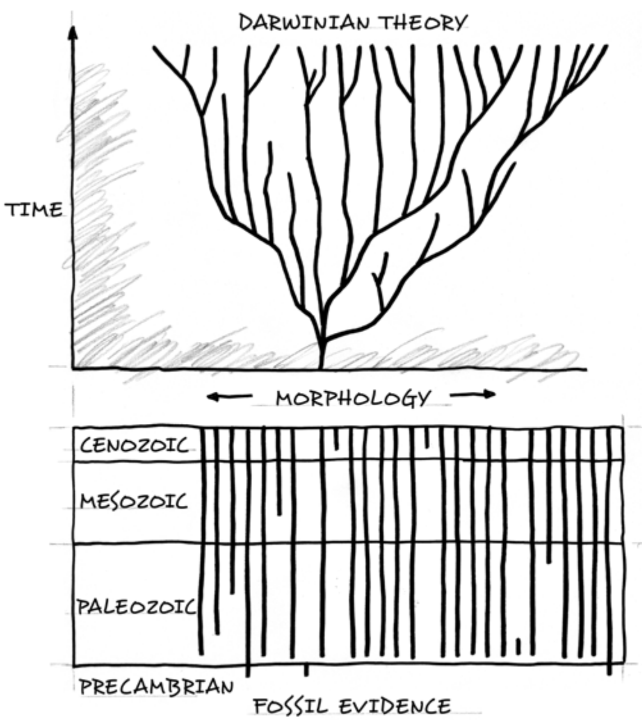


FIGURE 10.2

The origin of animals. Darwinian theory (top) predicts the gradual evolutionary change in contrast to the fossil evidence (bottom), which shows the abrupt appearance of the major animal groups.

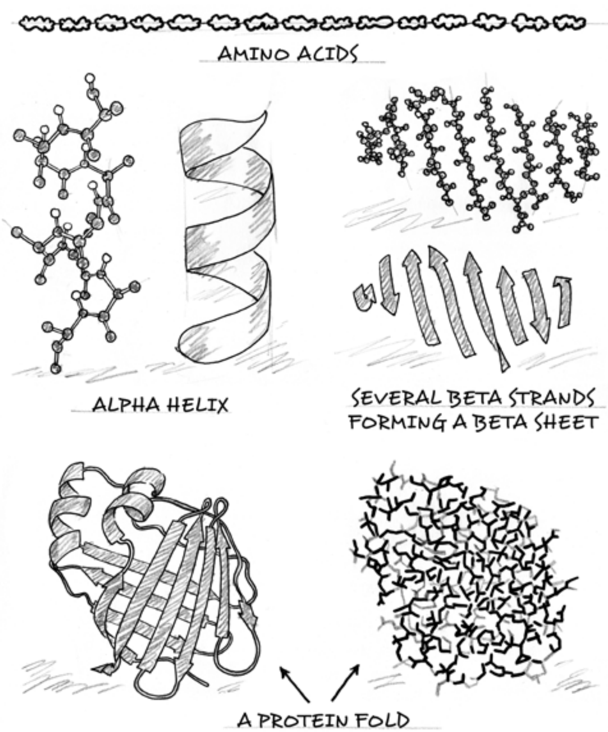


FIGURE 10.8

Different levels of protein structure. The first panel at the top shows the primary structure of a protein: a sequence of amino acids forming a polypeptide chain. The second panel depicts, in two different ways, two secondary structures: an alpha helix (left), and beta strands forming a beta sheet (right). The third panel at the bottom shows, in two different ways, a tertiary structure—that is, a protein fold. Protein folds represent the smallest unit of structural innovation in living systems.

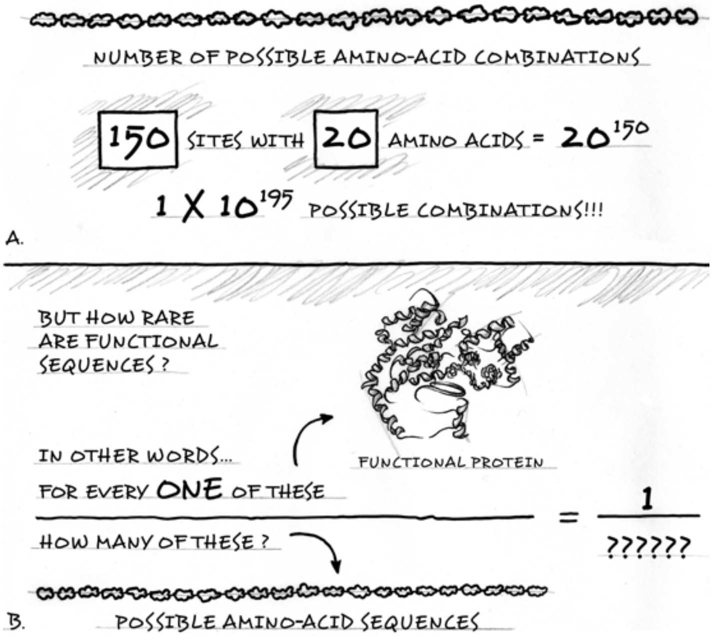


FIGURE 10.9

TOP: This depicts the problem of combinatorial inflation as it applies to proteins. As the number of amino acids necessary to produce a protein or protein fold grows, the corresponding number of possible amino acid combinations grows exponentially.

BOTTOM: This depicts graphically the question of the rarity of proteins in that vast amino acid "sequence space."

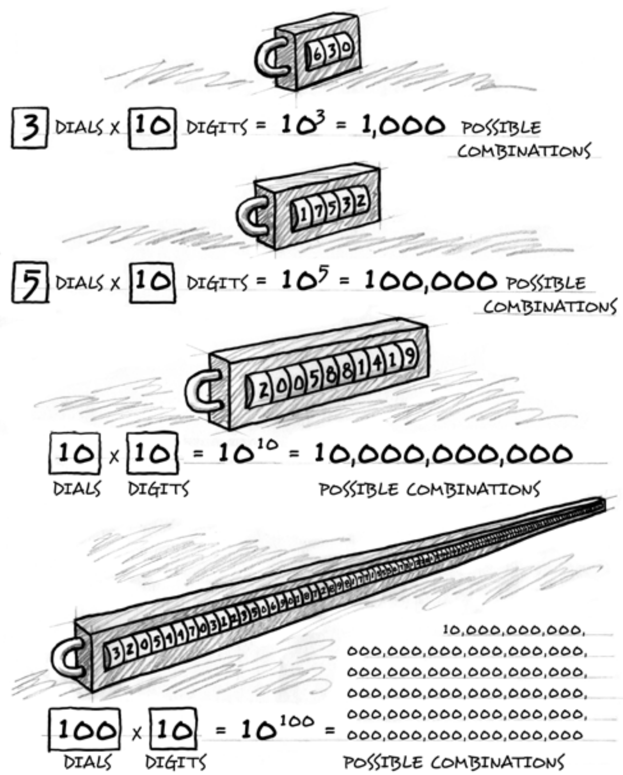


FIGURE 10.10

The problem of combinatorial inflation as illustrated by bike locks of varying sizes. As the number of dials on the bike locks increases, the number of possible combinations rises exponentially.

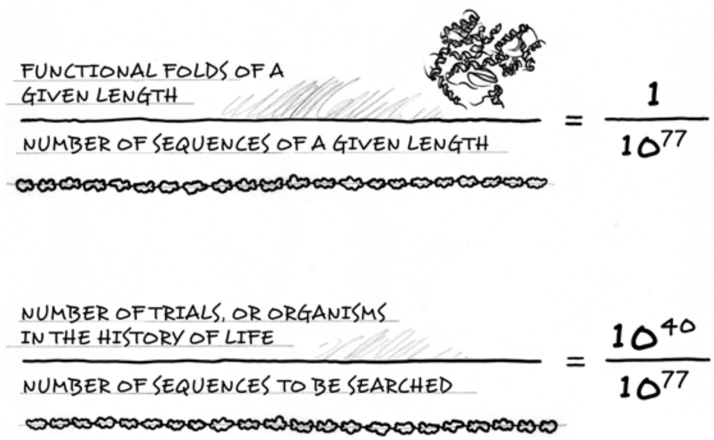


FIGURE 10.11

The top panel in this diagram represents the results of Axe's mutagenesis experiments showing the extreme rarity of functional proteins in sequence space. Based on his experiments Axe estimated that there are 10^{77} possible sequences corresponding to a specific functional sequence 150 amino acids long. The second panel shows that functional amino acid sequences are extremely rare even in relation to the total number of opportunities the evolutionary process would have had to generate novel sequences (on the assumption that each organism that has ever lived during the history of life produced one such new sequence per generation).

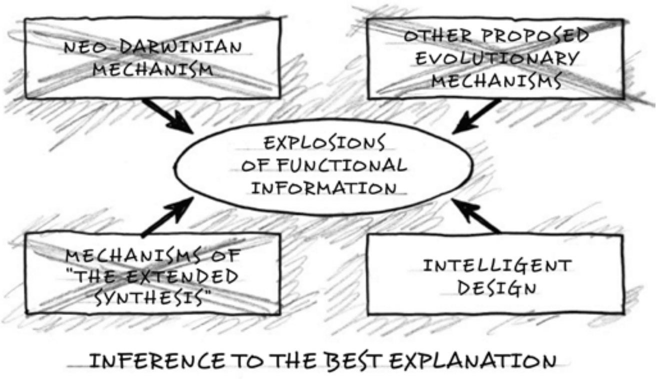


FIGURE 10.12

In this chapter, I show that the neo-Darwinian mechanism of random mutation and natural selection does not provide a plausible (or "causally adequate") explanation for the origin of the functional or specified information in living systems. In *Darwin's Doubt* and other published work, I also show that more recently proposed evolutionary mechanisms associated with the "extended synthesis," as well as those associated with theories of self-organization and punctuated equilibrium, also fail to explain the origin of the information necessary to build novel forms of life. These new evolutionary mechanisms—such as species selection, neutral evolution, natural genetic engineering, neo-Lamarckian epigenetic inheritance, niche construction, and evolutionary developmental processes— invariably either do not address the problem of the origin of genetic and ontogenetic information or they presuppose prior unexplained sources of such specified information. Yet, we know that intelligent agents can and do produce specified information. Consequently, I infer intelligent design as the best, most causally adequate explanation for the explosions of functional or specified information evident in the Cambrian explosion and other similar events in the history of life.

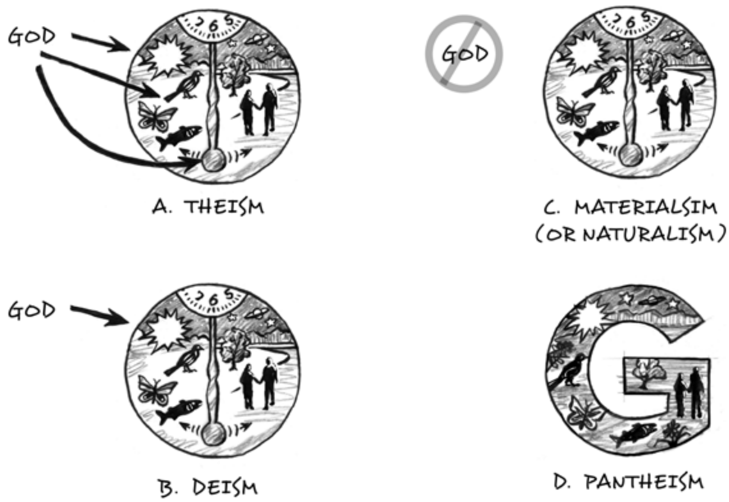


FIGURE 11.3

Philosophers recognize several main worldviews with different answers to the "prime reality" question. Theism affirms a personal, intelligent, transcendent God who also acts within the creation. Deism asserts a personal, transcendent, intelligent God who does *not* act within the created order after its initial origin. Naturalism (or materialism) affirms matter and energy and the laws of nature as the prime realities. Pantheism asserts an *impersonal* deity present in matter and energy as the prime reality. In these diagrams portraying these four great systems of thought, the circles represent the physical universe, the drawings inside the circle depict various living and nonliving entities within the universe, the pendulum represents the laws of nature, and "the big G" represents God. Notice that in Theism, God is depicted as separate from but also active in the universe; in Deism, God is depicted as separate from but not active in the universe; in Naturalism or Materialism, God is portrayed as nonexistent, and in Pantheism, God is shown as present in, or "co-extensive" with, every aspect of the material universe but not existing in any way separate from it.

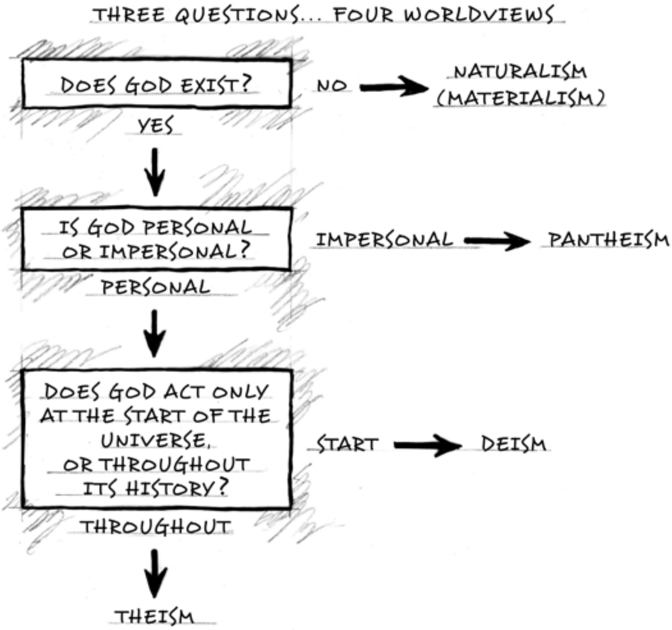


FIGURE 11.4

The four worldviews of theism, deism, pantheism, and materialism represent four possible ways of answering three basic questions about ultimate reality: Does God exist? If so, is God personal or impersonal? If personal, does God act only at the beginning of the universe or also after the beginning within the created order?

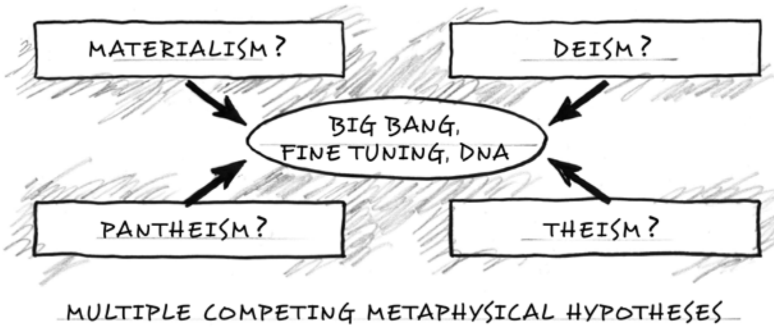


FIGURE 11.5

The chapters to follow will assess which of the competing metaphysical hypotheses or worldviews best explain the three key discoveries about the origin of the universe and life: (1) the universe had a beginning (the big bang); (2) the universe has been fine-tuned for the possibility of life from the beginning; and (3) large bursts of biological information (stored in DNA and elsewhere) have arisen in the earth's biosphere since the beginning of the universe making new forms of life possible.

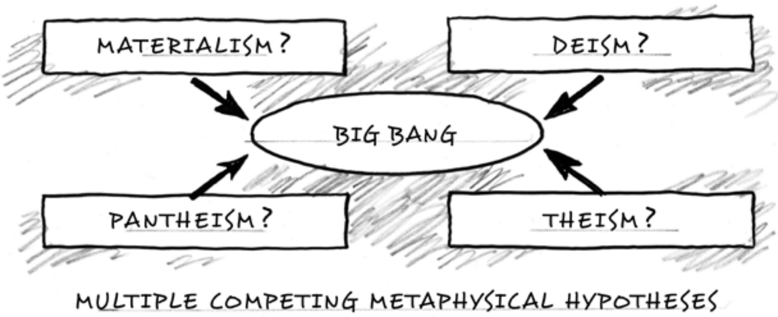


FIGURE 12.3

This chapter evaluates which of the competing metaphysical hypotheses or worldviews (theism, deism, pantheism, or materialism) best explains the evidence suggesting the universe had a beginning.

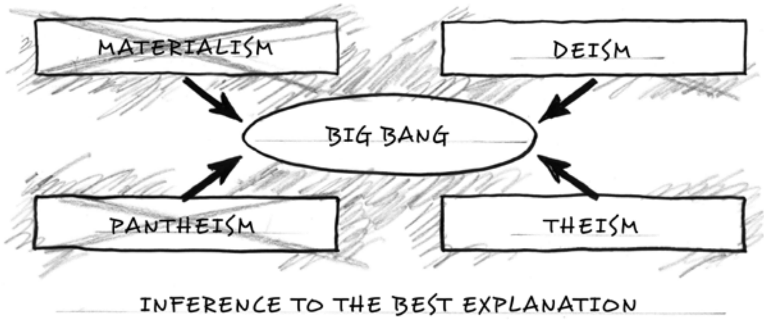


FIGURE 12.6

This chapter argues that theism and deism provide better, more causally adequate explanations for the origin of the universe—and the evidence that the universe had a beginning—than either materialism or pantheism.

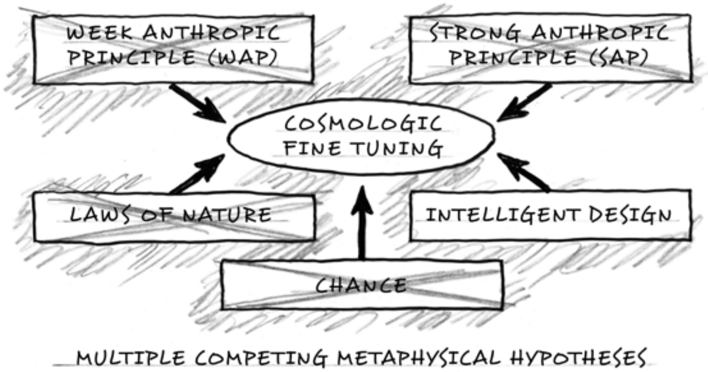


FIGURE 13.1

This chapter builds on the discussion in Chapters 7 and 8 in which I argued that intelligent design best explains the evidence of the fine tuning of the laws and constants of physics and the initial conditions of the universe. This chapter will also suggest that since this evidence of design is present from the beginning of the universe, it points to the need for a transcendent, rather than an immanent, intelligent agent as the best explanation. It does not yet consider the "exotic" naturalistic hypothesis of "the multiverse."

FIGURE 13.2

Some prominent biologists have proposed that life was seeded on earth by an extraterrestrial intelligence. While this hypothesis known as "panspermia" might in theory explain the evidence of design in living systems on earth, it cannot explain the origin or fine tuning of the universe, since both those events would have preceded all forms of life in the universes, including any putative intelligent aliens.

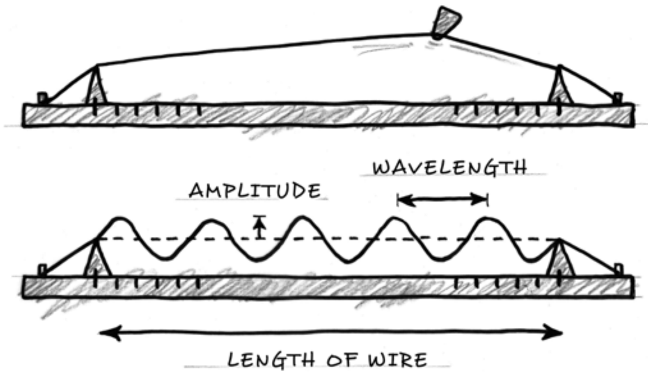


FIGURE 13.3

The top diagram depicts a wire between two pegs being plucked. The plucking results in the wire forming oscillating sine waves. The bottom diagram depicts the resulting wave form of a specific wavelength. The force of the plucking determines the amplitude (height) of the wave. The length between the pegs determines the possible wavelengths.

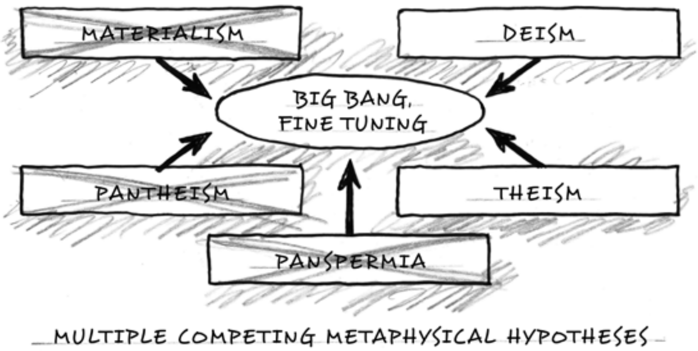


FIGURE 13.6

This chapter has evaluated which of the competing metaphysical hypotheses (theism, deism, pantheism, materialism, or panspermia) best explain the fine tuning of the universe. It has argued that theism and deism provide causally adequate explanations for this evidence whereas neither pantheism, materialism, or panspermia do. Similarly, neither pantheism, materialism, nor panspermia explain the evidence for the beginning of the universe as well as theism or deism do. Thus, given these two classes of evidence (i.e., the big bang and fine tuning), theism and deism remain as possibly the best explanations.

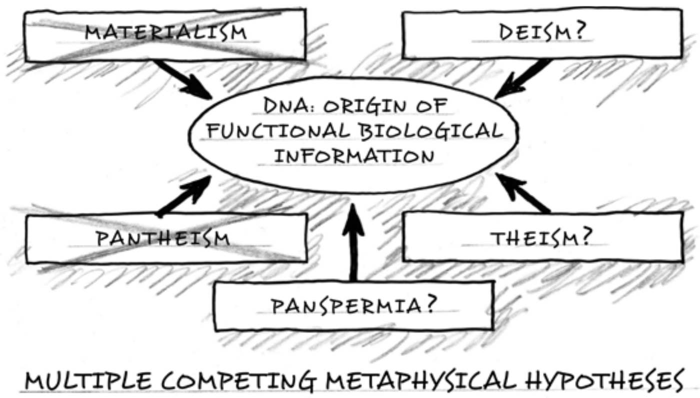


FIGURE 14.1

This chapter will evaluate whether theism or deism (or possibly panspermia) provides a better, more causally adequate explanation for the explosions of the functional biological information that have occurred in the history of life on earth.

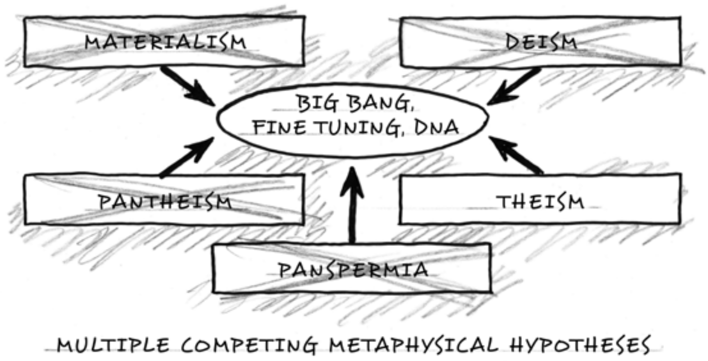


FIGURE 14.2

This chapter and the previous two have shown that only theism provides a causally adequate explanation for the whole ensemble of evidence about biological and cosmological origins under consideration. Deism can explain the origin of the universe and its fine tuning, but not subsequent infusions of functional biological information into the earth's biosphere. Panspermia might *in theory* explain the origin of biological information on earth, but it does not explain the ultimate origin of biological information. Nor can it explain the origin of the universe or its fine tuning. Materialism and pantheism fail to account for all three key classes of evidence since they deny a preexistent transcendent intelligence.

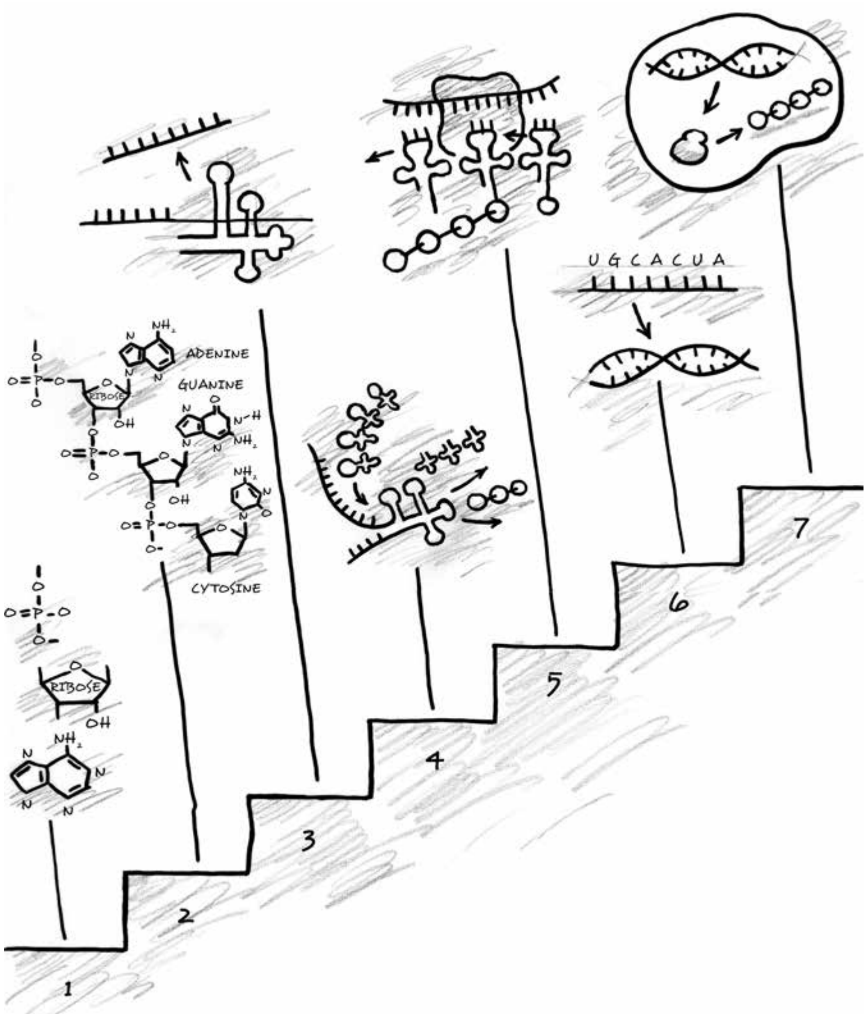


FIGURE 15.3

The RNA-world scenario in seven steps. *Step 1:* The building blocks of RNA arise on the early earth. *Step 2:* RNA building blocks link up to form RNA oligonucleotide chains. *Step 3:* An RNA replicase arises by chance and selective pressures ensue favoring more complex forms of molecular organization. *Step 4:* RNA enzymes begin to synthesize proteins from RNA templates. *Step 5:* Protein-based protein synthesis replaces RNA-based protein synthesis. *Step 6:* Reverse transcriptase transfers genetic information from RNA molecules into DNA molecules. *Step 7:* The modern gene expression system arises within a proto-membrane. Each of the steps in this scenario are biochemically implausible, particularly steps 3 and 4, which presuppose significant sources of unexplained genetic information.

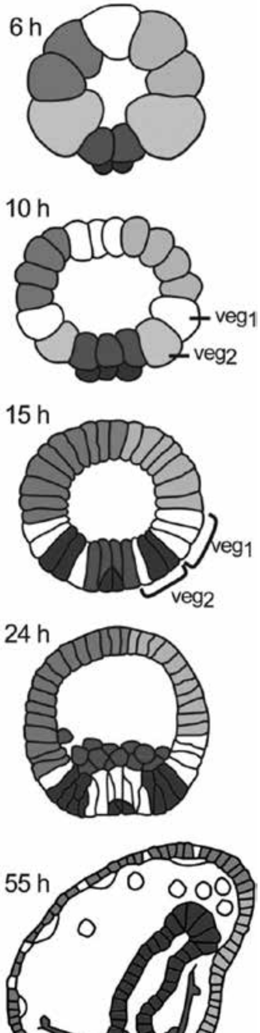


FIGURE 15.5A

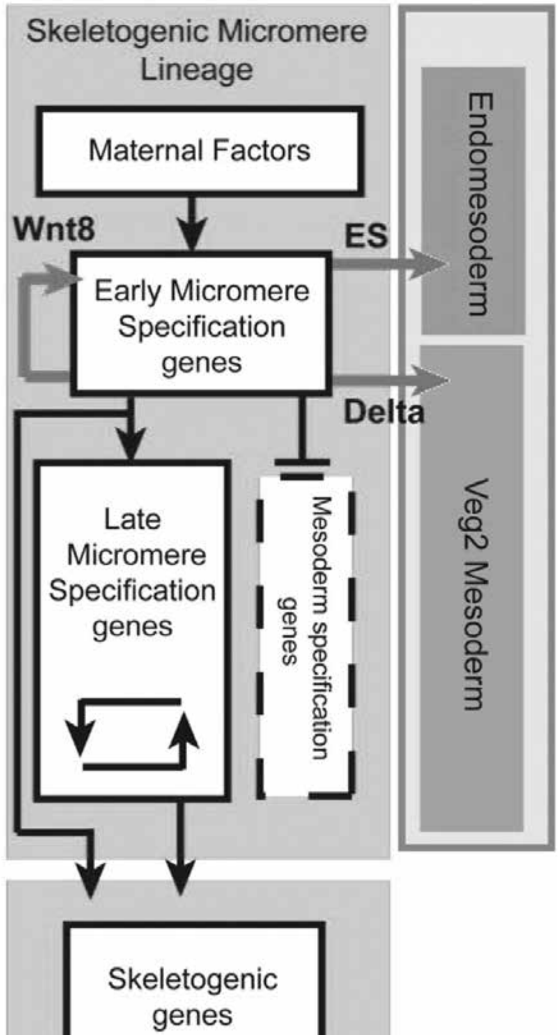
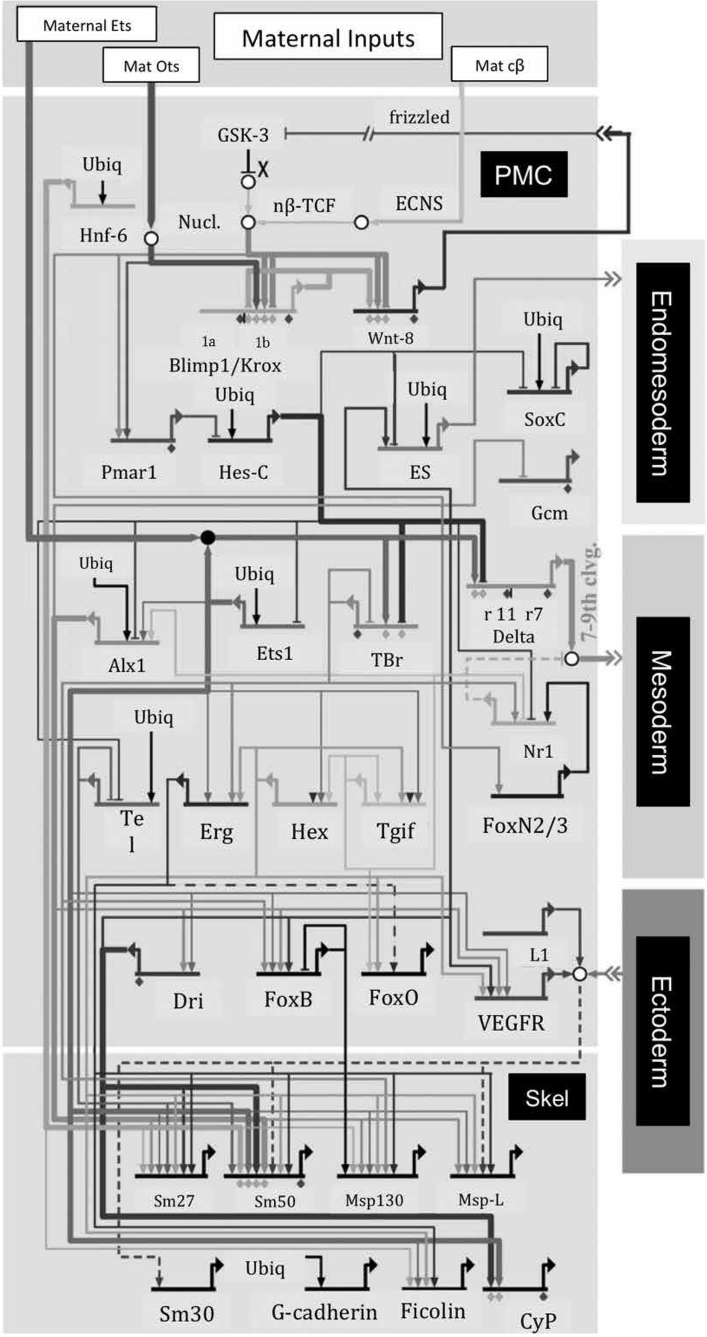


FIGURE 15.5B

Developmental gene regulatory networks (dGRNs) coordinate the timing and expression of genetic information during animal development from embryo to fully developed adult form. When developmental biologists map the functional relationships in these coordinated networks of genes and gene products (including proteins or regulatory RNAs) the resulting schematics look strikingly similar to integrated circuits. Figure 15.5a (left, above) shows the development of a purple sea urchin, *Strongylocentrotus purpuratus*, starting at six hours after fertilization and progressing through cell division to fifty-five hours when the larval skeleton appears. Figure 15.5b (right, above) depicts the major classes of genes involved in specifying the larval skeleton. Figure 15.5c (facing page) shows the detailed genetic circuitry implicated in the overall "gene regulatory network" controlling the construction of the larval skeleton.



Maternal Ets
Mat Ots
Maternal Inputs
Mat cβ
GSK-3
frizzled
PMC
Ubiq
nβ-TCF
ECNS
Nucl.
Hnf-6
Endomesoderm
1a
1b
Wnt-8
Blimp1/Krox
Ubiq
Ubiq
Ubiq
SoxC
Pmar1
Hes-C
ES
Gcm
Ubiq
Ubiq
7-9th clvg.
r 11 r7
Delta
Alx1
Ets1
TBr
Mesoderm
Ubiq
Nr1
Te
l
Erg
Hex
Tgif
FoxN2/3
L1
Dri
FoxB
FoxO
VEGFR
Ectoderm
Skel
Sm27
Sm50
Msp130
Msp-L
Ubiq
Sm30
G-cadherin
Ficolin
CyP

FIGURE 15.5C

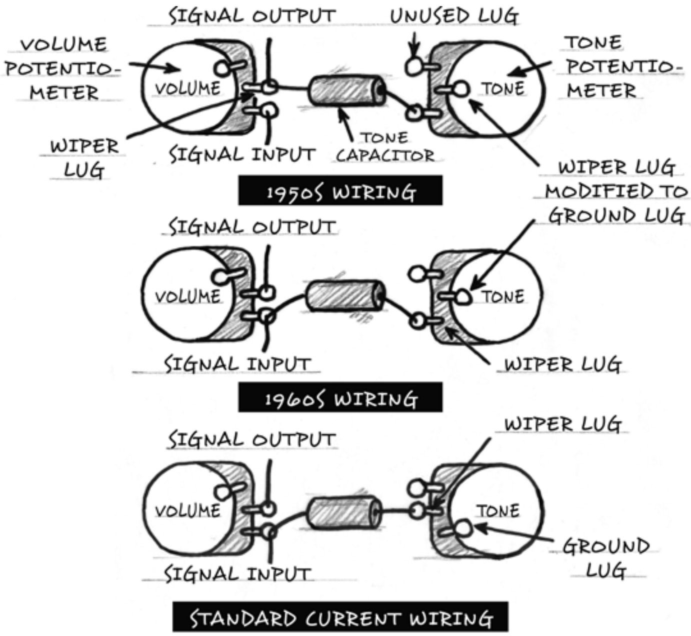


FIGURE 15.6

Three different circuitry designs for different electric guitars. Notice that though the material components of the three designs are the same in all three guitars, converting one design to another would require a reconfiguration of the parts and, thus, an input of information.

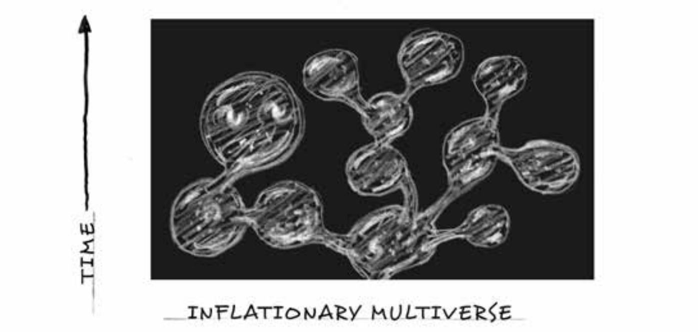


FIGURE 16.1

The inflationary multiverse envisions new universes emerging from older universes. To explain the rapid expansion of space (in all universes), it posits the existence of an inflaton field. To explain the origin of these new universes, it further posits that when the energy of the inflaton field shuts off in precise ways in local areas of individual universes, new "bubble" universes will emerge. Though these new universes would not have different laws and constants of physics, they could, according to proponents of this model, have quite different configurations of mass and energy, making the events and structures that exist in these new universes different from our own.

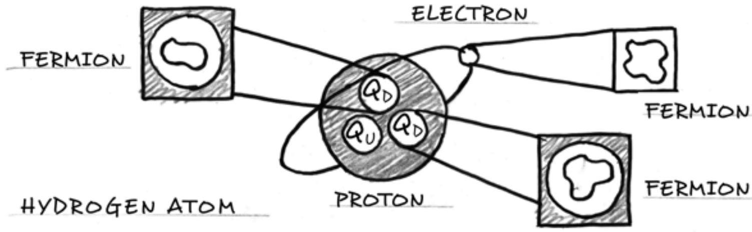


FIGURE 16.2

According to string theory, the fundamental units of matter are composed of vibrating filaments of energy called "strings." Elementary particles or "fermions" are made of "closed" strings. The particles called "bosons" that transmit the fundamental forces of physics are made of open strings. This figure shows the relationship between closed strings and the different elementary particles or fermions that constitute the hydrogen atom. It shows how, according to string theorists, different closed strings make up electrons as well as the "up quarks" and "down quarks" that in turn make up protons.

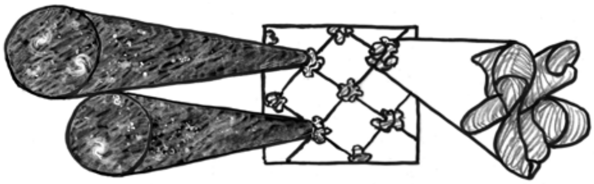


FIGURE 16.3

According to proponents of the string theoretic landscape, each solution to the string theoretic equations correspond to a multidimensional compactification of space containing different strings of energy. Proponents of the string landscape theorize that each of these compactifications (or vacua) could also correspond to a different universe with different laws and constants of physics. This diagram shows (on the right) a possible compactification of space, (in the middle) an ensemble of such compactifications and (on the left) two universes with presumably different sets of laws and constants of physics corresponding to two possible compactifications. The whole ensemble of possible compactifications or universes is known as the "string theoretic landscape."

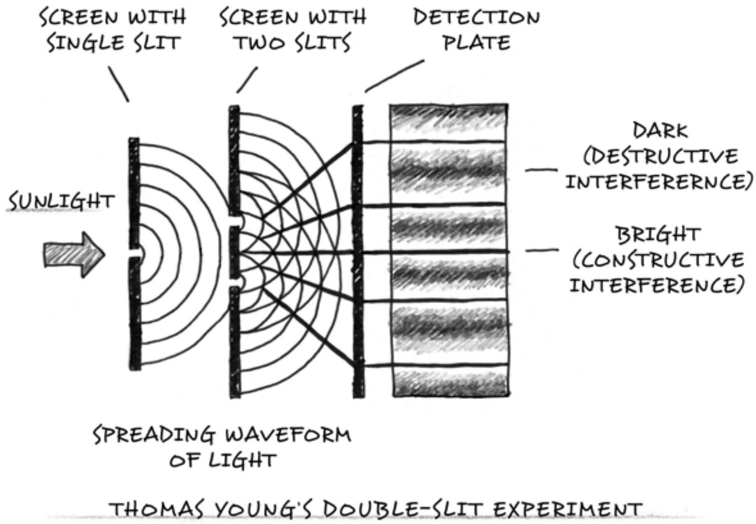


FIGURE 17.1

Interference pattern. When electrons or light with a specific frequency pass through two different slits, they produce an interference pattern on a terminal screen placed at a specific distance behind the slits. This pattern is the result of the waves from each slit either adding together or canceling each other out to form the corresponding light and dark lines. If a series of individual electrons or photons are emitted over time, the interference pattern will gradually appear. The individual electrons or photons passing through one of the slits act as though a wave has passed through both slits.

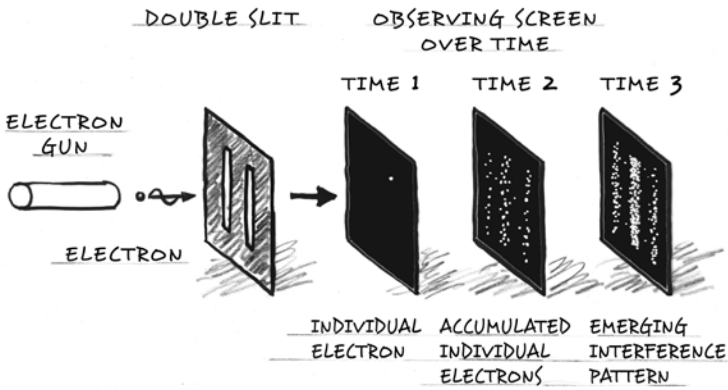


FIGURE 17.2A

Double-slit experiment (twentieth century). One version of the double-slit experiment uses an electron gun that emits individual electrons over an extended period of time. The electrons can pass through one of two slits and then hit a horizontal detection screen a specific distance beyond the slits. Over time, the distribution of detected electrons forms an interference pattern on the vertical detection screen demonstrating that electrons behave as *waves* with a characteristic wavelength.

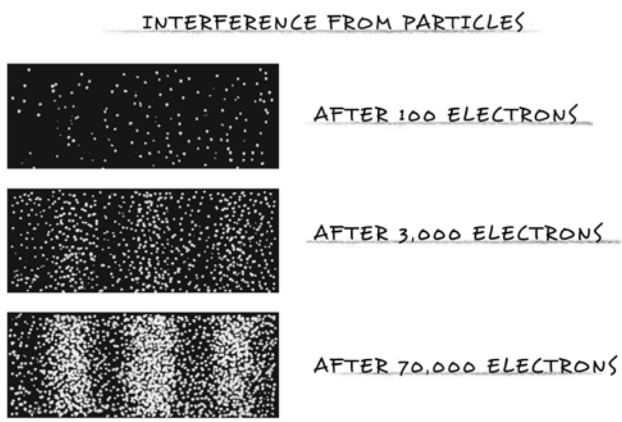


FIGURE 17.2B

Detection plate from a double-slit experiment. As electrons hit the vertical detection screen they initially create a fairly random scatter effect. But over time an interference pattern of light and dark bands emerges. The electrons hit with greater probability in the whiter regions than in the darker ones.

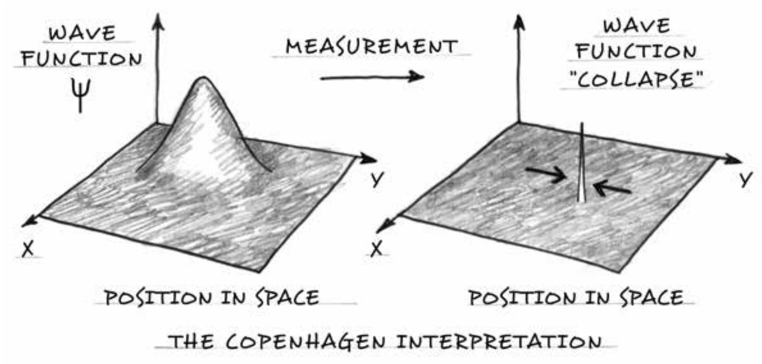


FIGURE 17.4

The Copenhagen interpretation of quantum mechanics. According to the Copenhagen interpretation of quantum mechanics, a proton or electron traveling through space exists in a "superposition" of possible positions (or possible values for its momentum) at the same time. What physicists call the "wave function" for such a quantum mechanical system represents the ensemble of possible states that the photon or electron might exhibit, and its magnitude squared equals the probability distribution for the position, momentum, or other variables taking on particular values when measured. When physicists take a measurement, the wave function "collapses" into a specific state corresponding to a specific measured value. For instance, if the position of a particle is measured, the wave function will collapse into a state corresponding to the specific measured position. The diagram illustrates how the wave function $\psi(x,y)$ initially has a broad peak representing many possible positions. After an apparatus measures the particle at a given position (x, y), the function becomes narrowly peaked at the measured position.

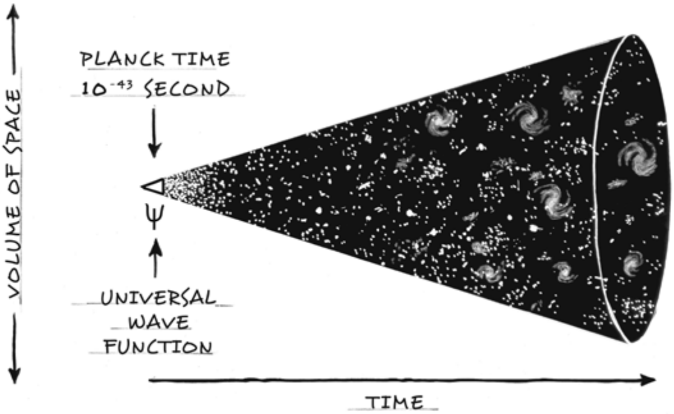


FIGURE 17.5

Quantum cosmology. Cosmologists have attempted to synthesize general relativity with quantum mechanics to generate "quantum cosmological" models for the earliest stage of the universe. Quantum cosmologists seek to determine a wave function for the universe, which they represent with the same Greek letter ψ as used in standard quantum mechanics. The ψ function describes different universes with different possible gravitational fields in "superposition." Knowing ψ allows physicists to calculate the probability that a specific universe with a specific gravitational field will appear, that is, a universe with a specific spatial geometry and matter field (and a resulting mass-energy configuration). Constructing a universal wave function allows physicists to calculate the probability that different possible universes with different gravitational fields existed "inside of" or will "emerge from" the universe as it existed inside "Planck time"—that is, in the first 10^{-43} seconds after the beginning of the universe when the universe would have been small enough to be subject to quantum effects.

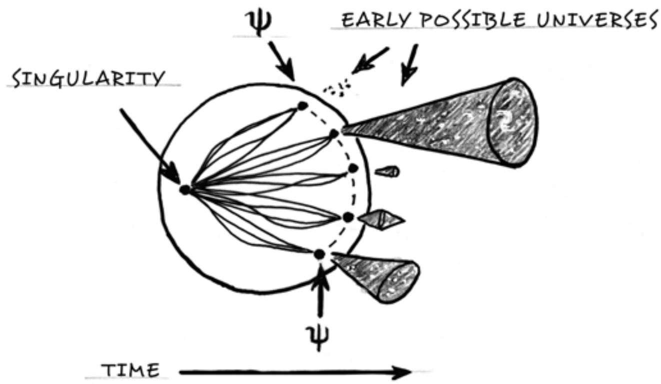


FIGURE 17.7

To solve the Wheeler-DeWitt equation physicists use a path-integral method that requires them to sum up the different mathematical expressions describing different paths from the singularity at the beginning of the universe to different possible universes with different gravitational fields. This diagram shows roughly what physicists envision their mathematical procedure representing. It shows the presumed singularity at the beginning of the universe, some of the different paths (through "superspace"), and an ensemble of possible universes (represented by the resulting universal wave function (Ψ).

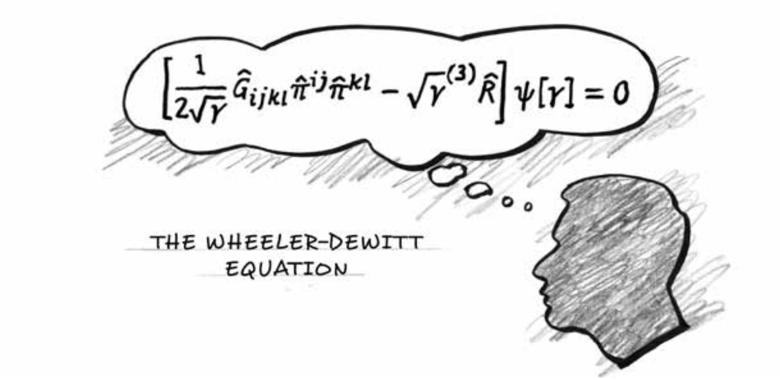


FIGURE 18.1

Matter out of math? Mathematical concepts, expressions, and equations exist in minds. That raises a profound question for quantum cosmologists. How do the mathematical expressions that they use to describe possible universes (or the early universe) cause an actual material universe to come into existence?

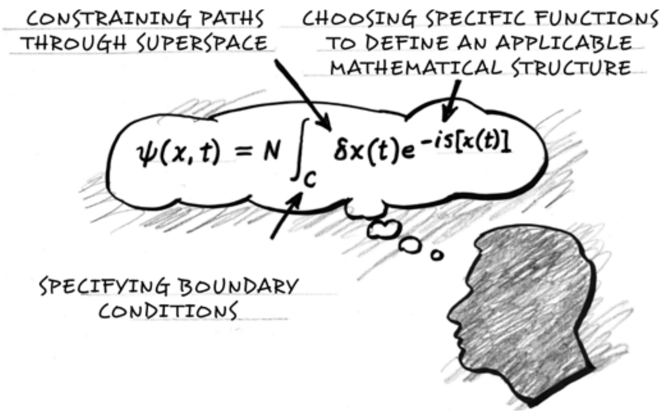


FIGURE 18.2

Solving the Wheeler-DeWitt equation allows quantum cosmologists to construct a universal wave function (Ψ) that describes possible universes with different possible gravitational fields. If our universe is included in the ensemble described by a universal wave function (Ψ), quantum cosmologists will regard (Ψ) as a description or explanation of the origin of the physical universe. This figure shows a mathematical expression called a "path integral" that is used to solve the Wheeler-DeWitt equation and construct the universal wave function (Ψ). The arrows point to variables, functions, and boundary conditions that must be specified to solve the path-integral (and, thus, the Wheeler-DeWitt equation). Because the path-integral, like the Wheeler-DeWitt equation, logically precedes any mathematical expression describing possible universes or the origin of them (as the universal wave function Ψ does), the path-integral does not itself describe a physical system. Consequently, there is no physical system that can determine the boundary conditions (or specify other mathematical parameters) that allow the path-integral to be solved. Instead, physicists themselves must determine these constraints. Quantum cosmologists invariably do this selectively with an end goal in mind, namely, constructing a universal wave function that includes a universe such as ours as a reasonably probable outcome.

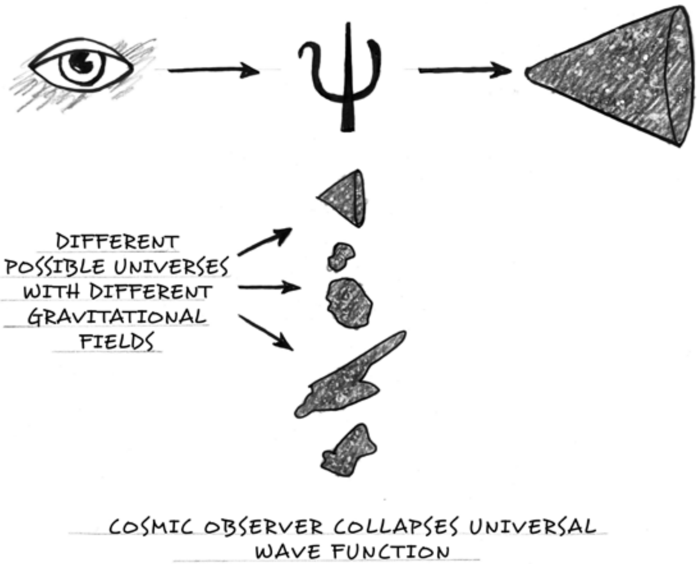


FIGURE 19.1

A Cosmic Observer? The traditional Copenhagen interpretation of the collapse of the wave function—when applied to the universal wave function in quantum cosmology—would seem to require a transcendent "Cosmic Observer" to cause the collapse and, thus, the emergence of a specific universe among the various possible universes described by the universal wave function.

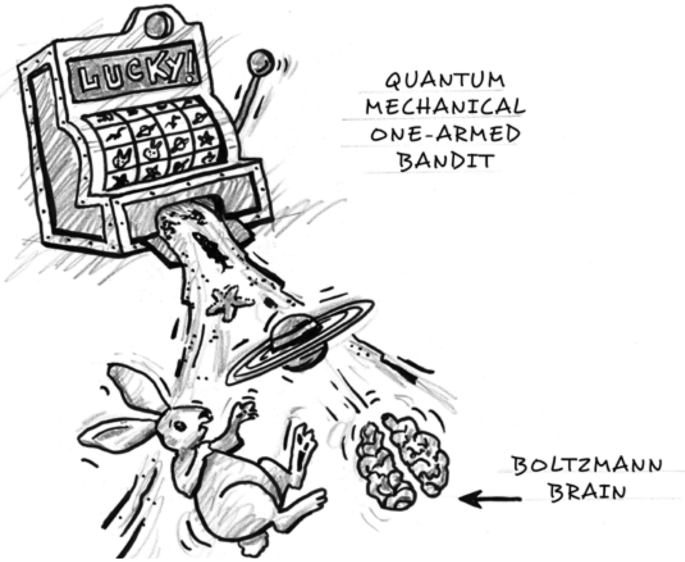


FIGURE 19.4

The Boltzmann brain problem. According to quantum mechanics, there is a finite, if extremely tiny, probability of random quantum fluctuations at a subatomic level occasionally generating unexpected macroscopic outcomes, including the production of fully formed persons with so-called Boltzmann brains containing false memories. Though such events would, in all probability, never happen if our solitary universe were the only universe, any event with a finite probability of occurrence, however small, will inevitably happen in an infinite multiverse. In such a multiverse, an infinite number of brains with false memories and perceptions would inevitably arise. More troubling, there are reasons to think that in such a multiverse we ourselves are more likely to have "Boltzmann brains" than "natural brains" with reliable perceptions and true memories.

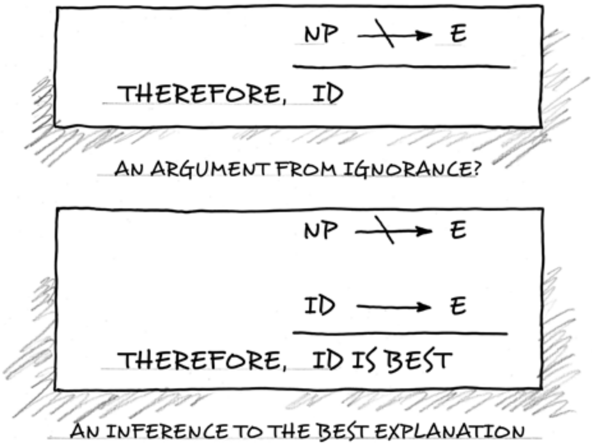


FIGURE 20.2

Some critics of intelligent design portray the case for intelligent design as a fallacious argument from ignorance. They claim proponents of the argument affirm intelligent design only because of the implausibility of various naturalistic processes (NP) as causal explanations for the origin of the specified information, the key effect (E) that needs to be explained in living systems. Nevertheless, the specified information of DNA implicates a prior intelligent cause, not only because various naturalistic or materialistic origin-of-life scenarios fail to explain it, but also because we *know* that intelligent agents can and do produce information of this kind. Thus, in addition to a premise about how natural processes lack causal adequacy, the argument for intelligent design (ID) presented here also cites evidence of the power of intelligent agents to produce functional or specified information. The argument as stated, thus, does not fail to provide a premise affirming positive evidence for the adequacy of a preferred cause. The argument specifically *includes* such a premise. Therefore, it does not commit a fallacious argument from ignorance. The fallacious form of the ID argument as portrayed by ID critics is depicted in the top half of this figure. The valid form of the argument presented in this book as an inference to the best explanation is depicted in the bottom half of the figure.

Notes

Prologue

1 "Krauss, Meyer, Lamoureux: What's Behind It All? God, Science and the Universe," March 2016, https://youtu.be/mMuy58DaqOk.
2 Because materialists claim that science supports this view, scholars refer to this philosophy as *scientific* materialism or sometimes *scientific* naturalism. Scientific naturalism refers to the closely related idea that the natural world—and the matter and energy out of which it is made—is *all* that ultimately exists.
3 See "Lost Between Immensity and Eternity: The Best of Carl Sagan's *Cosmos* (Part 2)," https://youtu.be/vIVsDg6U0LU?t=41.
4 Dawkins, *The Blind Watchmaker*, 1.
5 Nye, *Undeniable*, 46.
6 Dawkins, *The Blind Watchmaker*, 7.
7 Dennett, *Darwin's Dangerous Idea*, 63.
8 Krauss, *A Universe from Nothing.*
9 Hawking and Mlodinow, *The Grand Design*, 180.
10 West, *Darwin's Corrosive Idea*, 3–7.
11 Michael Lipka, "A Closer Look at America's Rapidly Growing Religious 'Nones,'" *Pew Research Center*, May 13, 2015, http://www.pewresearch.org/fact-tank/2015/05/13/a-closer-look-at-americas-rapidly-growing-religious-nones.
12 Dawkins, *The Blind Watchmaker*, 1, emphasis added.

Chapter 1: The Judeo-Christian Origins of Modern Science

1 Barash, "God, Darwin and My College Biology Class."
2 Dawkins, *River Out of Eden*, 133.
3 Albert B. Paine, *Mark Twain: A Biography*, *1835–1910* (1912), chap. 197, https://www.gutenberg.org/files/2988/2988-h/2988-h.htm#link2H_4_0102.
4 See Dawkins, *The God Delusion*, *River Out of Eden*, *The Blind Watchmaker*; Dennett, *Darwin's Dangerous Idea*; Harris, *The End of Faith*, *Letter to a Christian Nation*; Hitchens, *God Is Not Great*.
5 For a refutation of a corollary to this thesis, namely, the view that science has caused the secularization of society, see Brooke, "Myth 25."
6 Tyson, *Cosmos*, Episode 3.
7 Tyson, *Cosmos*, Episode 3, pg. 45 in the transcript, found at http://investigacion.izt.uam.mx/alva/cosmos2014_01-1.pdf. Also available in video form at https://www.fox.com/watch/cebd37976d6172a938ec77621fb35699/, timestamp 28:46.

8 Tyson, *Cosmos*, Episode 3, pg. 45 of the transcript, available at http://investigacion.izt.uam.mx/alva/cosmos2014_01-1.pdf. Also available in video form at https://www.fox.com/watch/cebd37976d6172a938ec77621fb35699/, timestamps 21:11 and 28:16.
9 See also Ungureanu, *Science, Religion, and the Protestant Tradition*.
10 Larson, *Summer for the Gods*, 21.
11 Draper, *History of the Conflict Between Religion and Science*, 363.
12 Russell, *Inventing the Flat Earth*, 38.
13 Larson, *Summer for the Gods*, 22.
14 Russell, "The Conflict of Science and Religion," 4.
15 Russell, "The Conflict of Science and Religion," 4.
16 Butterfield, *The Origins of Modern Science*.
17 Crombie, *The History of Science from Augustine to Galileo*, vol. 2.
18 Foster, *Creation, Nature, and Political Order in the Philosophy of Michael Foster (1903–1959)*.
19 Describing the origin of modern science, Loren Eiseley gave credit to "the sheer act of faith that the universe possessed order and could be interpreted by rational minds. . . . The philosophy of experimental science . . . began its discoveries and made use of its method in the faith, not the knowledge, that it was dealing with a rational universe controlled by a Creator who did not act upon whim nor interfere with the forces He had set in operation" (*Darwin's Century*, 62).
20 Lindberg, "Medieval Science and Religion."
21 Gingerich, *God's Universe*.
22 Hooykaas, *Religion and the Rise of Modern Science*.
23 Merton, "Science, Technology and Society in Seventeenth Century England."
24 Duhem, *The System of World*.
25 Russell, "The Conflict of Science and Religion"; *Cross-Currents*.
26 Whitehead, *Science and the Modern World*.
27 Hodgson, "The Christian Origin of Science"; *The Roots of Science and Its Fruits*; *Theology and Modern Physics*.
28 Barbour, *Religion and Science*.
29 Kaiser, *Creation and the History of Science*.
30 Rolston, *Science and Religion*.
31 Fuller, *Science vs. Religion?*
32 Harrison, *The Bible, Protestantism, and the Rise of Natural Science*; *The Fall of Man and the Foundations of Science*.
33 Stark, *For the Glory of God*.
34 Hodgson, "The Christian Origin of Science," *Occasional Papers*, 1. See also "The Christian Origin of Science," *Logos*, esp. 138.
35 Hodgson, "The Christian Origin of Science," *Occasional Papers*, 1. For an amplifying discussion and extended quotations, see Chapter 1, n. a, at www.returnofthegodhypothesis.com/extendedresearchnotes.
36 Barbour, *Religion and Science*, 27, emphasis in original.
37 Butterfield, *The Origins of Modern Science*, 16–17.
38 Lois Kieffaber, "Christian Theism Alive and Well in the Physics and Astronomy Classroom," in Arlin C. Migliazzo, ed., *Teaching as an Act of Faith: Theory and Practice in Church-Related Higher Education* (New York: Fordham Univ. Press, 2002), 121.
39 Hodgson, "The Christian Origin of Science," *Logos*, 142; Zilsel, "The Genesis of the Concept of Physical Law," 255.
40 Heraclitus and the Stoics represent the most famous of the Greeks to believe in the *logos*, but a similar concept, the *nous*, is also present in the works of Plato and Aristotle. Both "*logos* and *nous*," Richard Tarnas writes, "were variously employed to signify mind, reason, intellect, organizing principle, thought, word, speech, wisdom, and meaning, in each case relative to both human reason and a universal intelligence" (*The Passion of the Western Mind*, 47).
41 See Aristotle, *On the Heavens*; Ptolemy, *Almagest*.
42 Hooykaas, *Religion and the Rise of Modern Science*, 12.

43 The historian and philosopher of science Steve Fuller, of the University of Warwick, offers a different interpretation of the origin of the necessitarian thinking that Bishop Tempier condemned in 1277. In personal correspondence with me about this chapter, he notes that "by modern standards, most Greek philosophers—with the possible exception of Plato—were quite modest in what they thought 'science' of any sort could ultimately accomplish. (Consider the atomists. They definitely did not have an overblown conception of human reason.)" Instead, Fuller attributes the origin of necessitarian thinking less to Aristotle or Greek science generally and more to the influence of Islamic scholarship on the *interpretation* of Aristotle as his works came into currency in the Christian West during the twelfth and thirteenth centuries. For an amplifying discussion, see Chapter 1, n. b, at www.returnofthegodhypothesis.com/extendedresearchnotes.

44 See Boethius of Dacia, "On the Supreme Good; On the Eternity of the World; On Dreams"; Siger of Brabant, "On the Eternity of the World"; and Dales, *Medieval Discussions of the Eternity of the World*, for a thorough discussion of this subject.

45 Chaberek, *Aquinas and Evolution*, 48–59.

46 Crombie, *The History of Science from Augustine to Galileo*, 2:57. For an amplifying discussion and extended quotations, see Chapter 1, n. c, at www.returnofthegodhypothesis.com/extendedresearchnotes.

47 For example, Albertus Magnus (Crombie, *The History of Science from Augustine to Galileo*, 2:54), Pierre d'Auvergne, Jean Buridan, Marsilius of Inghen (2:54), Thierry of Chartres (1:49), and Averroës (1:72–73).

48 For example, Thierry of Chartres (Crombie, *The History of Science from Augustine to Galileo*, 1:49) and Averroës (1:72–73).

49 Klima, Allhoff, and Vaidya, eds., "Selections from the Condemnation of 1277."

50 Torrance, *Divine and Contingent Order*, 3.

51 For an amplifying discussion and extended quotations, see Chapter 1, n. d, at www.returnofthegodhypothesis.com/extendedresearchnotes.

52 Boyle, Royal Society, Miscellaneous MS 185, fol. 29, cited in Davis, "The Faith of a Great Scientist." For an amplifying discussion and extended quotations, see Chapter 1, n. e, at www.returnofthegodhypothesis.com/extendedresearchnotes.

53 Barbour, *Religion and Science*," 28, emphasis in original.

54 I often use the term "scientist" or "early modern scientist" anachronistically to describe those who, during the sixteen and seventeenth centuries, did what we would call scientific research today. At that time they were actually called "natural philosophers," "experimental philosophers," or "mechanical philosophers." The term "scientist" was not used to describe those who systematically study nature until 1833, when the philosopher of science William Whewell first coined it.

55 Whitehead, *Science and the Modern World*, 3–4, emphasis in original.

56 Whitehead, *Science and the Modern World*, 12.

57 Fuller, *Science vs. Religion?*, 15.

58 Rolston, *Science and Religion*, 39.

59 Kepler, Letter to Herwart von Hohenburg.

60 Hodgson, "The Christian Origin of Science," *Logos*, 145. For an amplifying discussion and extended quotations, see Chapter 1, n. f, at www.returnofthegodhypothesis.com/extendedresearchnotes.

61 Fuller, Foreword, in *Theistic Evolution*, 30. See also Harrison, *The Bible, Protestantism, and the Rise of Natural Science*; *The Fall of Man and the Foundations of Science*.

62 Fuller, Foreword, in *Theistic Evolution*, 30.

63 Fuller, Foreword, in *Theistic Evolution*, 30.

64 Harrison, *The Bible, Protestantism, and the Rise of Natural Science*; *The Fall of Man and the Foundations of Science*.

65 Fuller, Foreword, in *Theistic Evolution*, 31.

66 Crombie, *Robert Grosseteste and the Origins of Experimental Science 1100–1700*, 139–62.

67 Crombie, *Robert Grosseteste and the Origins of Experimental Science 1100–1700*, 52–57,

81–90. Grosseteste's method of "Resolution and Composition" involved induction from particulars to universals, and vice versa (see pp. 52–57), whereas his method of "Verification and Falsification" described the gradual elimination of variables to find the true cause of a given phenomenon and to affirm the correct hypothesis (see pp. 81–90; or chap. 4 for more detail).

68 Crombie, *The History of Science from Augustine to Galileo*, 2:27.
69 Lewis, "Robert Grosseteste."
70 See McGrade, "Natural Law and Moral Omnipotence," 273–301.
71 Spade, "Ockham's Nominalist Metaphysics: Some Main Themes," 101.
72 Aristotle, *Metaphysics* 1.3, 7-8.
73 Moliére uses this phrase in his play *The Imaginary Invalid* to make fun of a group of physicians explaining the dormitive powers of opium in this way.
74 See Spade, "Ockham's Nominalist Metaphysics."
75 See Freddoso, "Ockham on Faith and Reason," 328–31.
76 Ockham, Sent. I.30.1 (290), in Spade, "Ockham's Nominalist Metaphysics," 104.
77 Dawkins, *River Out of Eden*, 133.

Chapter 2: Three Metaphors and the Making of the Scientific World Picture

1 Hess, "God's Two Books"; Howell, *God's Two Books*. For an amplifying discussion and extended quotations, see Chapter 2, n. a, at www.returnofthegodhypothesis.com /extendedresearchnotes.
2 Socrates Scholasticus, *Historia Ecclesiastica*, IV, 23 (67, 518), cited in Tanzella-Nitti, "The Two Books Prior to the Scientific Revolution."
3 Basil of Caesarea, *Homilia de Gratiarum Actione*, 2 (PG 31, 221C–224A), cited in Tanzella-Nitti, "The Two Books Prior to the Scientific Revolution."
4 See Augustine, *Enarrationes in Psalmos*, *Sermones*, *Confessiones*; Maximus the Confessor, *Ambigua*; Aquinas, *Super Epistolam ad Romanos*, *Summa Theologiae*, cited in Tanzella-Nitti, "The Two Books Prior to the Scientific Revolution."
5 Ps. 19:1.
6 Ps. 19:2, emphasis added.
7 Rom. 1:20.
8 Ray, *The Wisdom of God Manifested in the Works of the Creation*.
9 Boyle, "Of the Study of the Book of Nature," 154–55, cited in Davis, "The Faith of a Great Scientist."
10 Boyle, "Of the Study of the Book of Nature," 154–55, cited in Davis, "The Faith of a Great Scientist."
11 The metaphor of nature as a book lingered in common usage among scientists long after it first gained currency during the scientific revolution. Albert Einstein used an adapted version of the metaphor in which he refers to the universe as a library of books intelligently arranged in a definite but, to us, mysterious order. As he explained: "We are in the position of a little child, entering a huge library whose walls are covered to the ceiling with books in many different tongues. The child knows that someone must have written those books. It does not know who or how" (quoted in Viereck, *Glimpses of the Great*, 372–73). For the extended quotation, see Chapter 2, n. b, at www.returnofthe godhypothesis.com/extendedresearchnotes.
12 Boyle, "Usefulness of Natural Philosophy," cited in Davis, "The Faith of a Great Scientist."
13 Boyle, "Usefulness of Natural Philosophy," cited in Davis, "The Faith of a Great Scientist."
14 Oresme, *Le Livre du ciel et du monde*.
15 Boyle, "A Free Enquiry into the Vulgarly Receiv'd Notion of Nature" (emphasis in original), cited in Davis, "The Faith of a Great Scientist."

16 Newton, in his *Opticks*, writes: "To tell us that every Species of Things is endow'd with an occult specifick Quality by which it acts and produces manifest Effects, is to tell us nothing" (401). For an amplifying discussion and extended quotations, see Chapter 2, n. c, at www.returnofthegodhypothesis.com/extendedresearchnotes.
17 Corpuscularian theories were proposed by, besides Boyle, Descartes (*The World*), Gassendi (*Opera Omnia*), Newton (*Opticks*), and Locke (*An Essay Concerning Human Understanding*).
18 Boyle, *New Experiments Physico-Mechanical*.
19 Boyle, *A Defense of the Doctrine Touching the Spring and Weight of the Air*.
20 Boyle, "A Free Enquiry into the Vulgarly Receiv'd Notion of Nature," 450–60, cited in Davis, "The Faith of a Great Scientist."
21 Boyle, "A Free Enquiry," 448.
22 Boyle, "Disquisition about the Final Causes of Natural Things," 150–51, cited in Davis, "The Faith of a Great Scientist."
23 Boyle, "Final Causes," 150–51.
24 Boyle, "Final Causes," 150–51, emphasis in original.
25 Boyle, "Final Causes," 150–51, emphasis in original.
26 Davis, "The Faith of a Great Scientist."
27 Davis, "The Faith of a Great Scientist."
28 For an alternate view of the effect of Darwin's theory on the reception of Paley's design argument, see Shapiro, "Myth 8."
29 Boyle, Royal Society, Boyle Papers, vol. 5, fol. 105, cited in Davis, "The Faith of a Great Scientist."
30 Boyle, Royal Society, Boyle Papers, vol. 5, fol. 105, cited in Davis, "The Faith of a Great Scientist."
31 Brooke, "Science and Theology in the Enlightenment," 9.
32 Calvin, *Chemical Evolution*, 258.
33 Calvin, *Chemical Evolution*, 258.
34 Calvin, *Chemical Evolution*, 258.
35 Zilsel, "The Genesis of the Concept of Physical Law," 245–47. For more recent scholarship exploring this connection, see Harrison, "The Development of the Concept of Laws of Nature." See also Gingerich, "Kepler and the Laws of Nature," 17–23; and Daston and Stolleis, *Natural Law and Laws of Nature in Early Modern Europe*.
36 Zilsel, "The Genesis of the Concept of Physical Law," 247–49.
37 Zilsel, "The Genesis of the Concept of Physical Law," 247–49.
38 Job 28:25–26: "When he gave to the wind its weight and apportioned the waters by measure, when he made a decree for the rain and a way for the lightning of the thunder."
39 Zilsel, "The Genesis of the Concept of Physical Law," 247–48. Ps. 104:9: "The Lord has set a boundary to the waters that they may not pass over"; Prov. 8:29: "The Lord gave his decree to the sea that the waters should not pass his commandment"; Jer. 5:22: "The Lord has placed the sand for the bound of the sea by a perpetual decree"; Job 26:10: "The Lord made a boundary to the water, until light and darkness come to an end."
40 Zilsel, "The Genesis of the Concept of Physical Law," 248.
41 Zilsel, "The Genesis of the Concept of Physical Law," 248.
42 Zilsel, "The Genesis of the Concept of Physical Law," 249–53. For an amplifying discussion and extended quotations, see Chapter 2, n. d, at www.returnofthegodhypothesis.com/extendedresearchnotes.
43 Zilsel, "The Genesis of the Concept of Physical Law," 250.
44 Zilsel, "The Genesis of the Concept of Physical Law," 250.
45 Zilsel, "The Genesis of the Concept of Physical Law," 251. For an extended quotation, see Chapter 2, n. e, at www.returnofthegodhypothesis.com/extendedresearchnotes.
46 Zilsel, "The Genesis of the Concept of Physical Law," 255.

47 Gingerich, "Kepler and the Laws of Nature," 17–23.
48 See Zilsel, "The Genesis of the Concept of Physical Law," 258ff.
49 Zilsel, "The Genesis of the Concept of Physical Law," 254.
50 Zilsel, "The Genesis of the Concept of Physical Law," 254. For an amplifying discussion and extended quotations, see Chapter 2, n. f, at www.returnofthegodhypothesis.com/extendedresearchnotes.
51 Oakley, "Christian Theology and the Newtonian Science," 435.
52 These ideas may, interestingly, be suggested by the biblical terminology. The Hebrew word *chok*, or "decree," shares a root with the verb that means "to carve," which is "to impress" words or images on a substance. It has a different connotation from another word used to mean something similar, *mishpat*, often translated as "judgment." Divine decrees of the first type have what may seem like a willful, even arbitrary quality, their reasons not necessarily known (Rashi [Rabbi Shlomo Yitzchaki, 1040–1105] and Rabbeinu Bachya [Bahya ibn Paquda, 1050–1120] on Numbers 19:1). On the other hand, the rationales behind God's "judgments" are clearer, and some could potentially be predicted as logically necessary to a justly ordered society.
53 Oakley, "Christian Theology and the Newtonian Science," 436–37.
54 Newton held this view. He wrote in the preface to the *Principia* that the natural philosophers of the seventeenth century were rightly "rejecting substantial forms and occult qualities" so they could "reduce the phenomena of nature to mathematical laws" (*Mathematical Principles of Natural Philosophy*, 381).
55 Descartes, *Principles of Philosophy*.
56 Huygens, "Discours de la Cause de la Pesanteur."
57 Davis, "Newton's Rejection of the 'Newtonian World View.'"
58 As Leibniz argued: "The Assertors of them [miraculous gravitational attractions] must suppose to be effected by *Miracles*, or else have recourse to Absurdities, that is, to the occult Qualities of the schools; which some Men begin to revive under the specious Name of *Forces*; but they bring us back again into the Kingdom of Darkness" (*A Collection of Papers, Which Passed Between the Late Learned Mr. Leibnitz* [*sic*] *and Dr. Clarke, in the Years 1715 and 1716*, 265, emphasis in original).
59 Leibniz, *New Essays on Human Understanding*, 66.
60 For an amplifying discussion and extended quotations from Leibniz, see Chapter 2, n. g, at www.returnofthegodhypothesis.com/extendedresearchnotes.
61 Leibniz, *Die Philosophischen Schriften*, 358.
62 Leibniz, *The Leibniz-Clarke Correspondence*, 94.
63 Leibniz, *The Leibniz-Clarke Correspondence*, 94.
64 Leibniz, *The Leibniz-Clarke Correspondence*, 92.
65 Leibniz, "New Essays on Human Understanding," 66; Allen, *Mechanical Explanations and the Ultimate Origin of the Universe According to Leibniz*, 8; Buchdahl, *Metaphysics and the Philosophy of Science*, 426; Leibniz, *The Leibniz-Clarke Correspondence*, 19.
66 Allen, *Mechanical Explanations and the Ultimate Origin of the Universe According to Leibniz*, O.
67 Allen, *Mechanical Explanations and the Ultimate Origin of the Universe According to Leibniz*, W.
68 Newton, *Cambridge Manuscript Add. 3970.3*, *478v*.
69 Newton, Letter from Isaac Newton to Richard Bentley, February 25, 1692/3, 189.R.4.47, 7r–7v.
70 Newton, Letter from Isaac Newton to Richard Bentley, February 25, 1692/3, 189.R.4.47, W.
71 See Bentley's seventh and eighth Boyle lectures, in Bentley, *Eight Sermons Preach'd at the Honourable Robert Boyle's Lecture, in the First Year 1692*.
72 Bentley, Letter from Richard Bentley to Isaac Newton, February 18, 1692/3, 189.R.4.47, ff.3–4.

73 Bentley, Letter from Richard Bentley to Isaac Newton, February 18, 1692/3, 189.R.4.47, 3r, emphasis added.
74 Newton, Letter from Isaac Newton to Richard Bentley, February 25, 1692/3, 189.R.4.47, 7r, emphasis added.
75 Newton, *Mathematical Principles of Natural Philosophy*, 941, emphasis added.
76 Collingwood, *The Idea of Nature*.
77 As Samuel Clarke, Newton's frequent spokesman, wrote, the course of nature is "nothing else but the will of God producing certain effects in a continued, regular, constant and uniform manner" (Yenter, "Samuel Clarke"; citations within are from Clarke, *The Works*, 698; *A Demonstration of the Being and Attributes of God and Other Writings*, 149).
78 Davis, "Newton's Rejection of the 'Newtonian World View.'"
79 Schaffer, "Occultism and Reason," 129; Davis, "Newton's Rejection of the 'Newtonian World View.'"
80 Gillespie, "Natural History, Natural Theology, and Social Order."
81 Kepler, *Mysterium Cosmographicum*, 93–103; *Harmonies of the World*, 170, 240; Gingerich, "Kepler and the Laws of Nature," 17–23.
82 Boyle, *Selected Philosophical Papers of Robert Boyle*, 172.
83 As historian of science James Larson has noted: "Rational inquiry must inevitably, in Linné's [Linnaeus's] opinion, lead, not to skepticism or disbelief, but to the acknowledgement of and respect for an omniscient and omnipotent creator" (*Reason and Experience*, 151).
84 Newton, *Opticks*, 369–70.
85 Newton, *The Mathematical Principles of Natural Philosophy*, trans. Motte, 388. The more recent Cohen and Whitman translation renders this passage as: "This most elegant system of the sun, planets, and comets could not have arisen without the design and dominion of an intelligent and powerful being." *Mathematical Principles of Natural Philosophy*, 942.
86 Brooke, "Science and Theology in the Enlightenment," 8–9.
87 Newton, *Opticks*, 370.

Chapter 3: The Rise of Scientific Materialism and the Eclipse of Theistic Science

1 Intellectual historians recognize different strands of Enlightenment philosophy, some more secularizing than others. French Enlightenment figures such as Voltaire tended to advance a more atheistic and anticlerical perspective, while British Enlightenment figures such as John Locke saw both human reason and scriptural revelation as valid and complementary sources of knowledge. The Scottish Enlightenment figure David Hume, though British, is well known for his skepticism about arguments for the existence of God and the possibility of miracles. Ironically, he also expressed profound skepticism about the use of inductive reasoning in scientific investigation (see p 52).
2 Ross, "Scientist: The Story of a Word," 72.
3 Hume further insisted that there *must* "be a uniform experience against every miraculous event, otherwise the event would not merit that appellation. And as uniform experience amounts to a proof, there is here a direct and full proof, from the nature of the fact, against the existence of any miracle" ("An Enquiry Concerning Human Understanding," 114).
4 Markie, "Rationalism vs. Empiricism."
5 Hume, "An Enquiry Concerning Human Understanding," 114. Many philosophers today think that Hume's skeptical argument against miracles depends upon a circular justification (begs the question), because he dismisses all alleged historical evidence for

the occurrence of miracles on the grounds that miracles do not happen and then justifies the claim that miracles do not happen by asserting that they have never been observed. His critique of the possibility of miracles also assumes that they violate the laws of nature, yet in other parts of "An Enquiry Concerning Human Understanding" (e.g., 46) he argues that the laws of nature lack objective existence, but instead represent mere habits of cognition in our minds. But if that is so, it is hard to see how miracles "violate" them. See McGrew, "Miracles."

6 See Comte, "The Positive Philosophy of Auguste Comte."

7 For more on Kant's view of the cosmological argument, see Kant, *The Critique of Pure Reason*, *The Critique of Practical Reason and Other Ethical Treatises*, *The Critique of Judgement*, 368–70, 440–56; for Kant on the design argument, see 523.

8 Craig, *Reasonable Faith*, 79–83.

9 Craig, *The Cosmological Argument from Plato to Leibniz*, x, xi, 48–126, 158–204, 282–95; Craig, *Reasonable Faith*, 79–80; Swinburne, *The Existence of God*, 116–32.

10 Bonaventure. *Commentaries on the Sentences of Peter Lombard*, Book II, Distinction 1, Part 1, Article 1, Question 1.

11 Kant, *The Critique of Pure Reason*, *The Critique of Practical Reason and Other Ethical Treatises*, *The Critique of Judgement*, 368–70.

12 Kant, *The Critique of Pure Reason*, *The Critique of Practical Reason and Other Ethical Treatises*, *The Critique of Judgement*, 440–56.

13 The Kalām cosmological argument attempts to argue for the existence of God as a necessary first cause for the origin of a finite universe. The Kalām argument is not the only version of the cosmological argument, however. Thomas Aquinas argued for God as a necessary first cause of the universe, not in a temporal sense, but in an ontological sense (Craig, *Reasonable Faith*, 80–83). Gottfried Leibniz championed another version of the cosmological argument in which he postulated God as the only "sufficient reason" for the contingent causal structure of the universe as a whole ("The Monadology," 235–38). For additional discussion of the status and impact of these versions of the cosmological argument, see Chapter 3, n. a, at www.returnofthegodhypothesis.com /extendedresearchnotes.

14 Newton, *The Correspondence of Isaac Newton*, vol. 3, letter 398.

15 Hawking, *A Brief History of Time*, 9.

16 As H. S. Thayer writes, "Newton speaks, in the *Optics*, of space as the *divine sensorium*; space is that in which the power and will of God directs and controls the physical world. Space is not to be identified with God. . . . Newton says in this scholium that God 'governs all things, and knows all that are or can be done. He is not eternity or infinity, but eternal and infinite; He is not duration or space, but he endures and is present. He endures forever, and is everywhere present; and by existing always and everywhere, he constitutes duration and space.' God constitutes duration and space since 'by the same necessity [as he exists] he exists *always* and *everywhere*'" (*Newton's Philosophy of Nature*, 185–86).

17 Newton likely believed that the material contents of the universe were created a finite time ago, but that time had existed infinitely far back. Gorham, "Newton on God's Relation to Space and Time," 281–320.

18 Even so, few physicists and astronomers during the nineteenth century articulated this view explicitly. Rather, with the rise of scientific materialism, many scientists and philosophers simply seemed to assume that the universe must be eternal and self-existent. Consequently, the discovery of evidence supporting a temporally finite universe during the early part of the twentieth century induced significant cognitive dissonance among many physicists and astronomers. Their reaction clearly revealed that during the nineteenth century the assumption of an infinitely old universe had become deeply entrenched. The most prominent example of this adverse reaction was Einstein's decision to select a precise value for the cosmological constant to ensure that he could depict the universe as neither expanding nor contracting but static. Sir Arthur

Eddington and Sir Fred Hoyle also reacted negatively to the idea of a temporally finite universe. See Chapter 5, where I discuss each of these examples in greater detail.

19 Hume, "Dialogues Concerning Natural Religion," 51.

20 Hume, "Dialogues Concerning Natural Religion," 72–83.

21 Hume, "Dialogues Concerning Natural Religion," 72–83. In Hume's "Dialogues," his character Philo says: "I affirm that there are other parts of the universe (besides the machines of human invention) which bear still a great resemblance to the fabric of the world, and which therefore afford a better conjecture concerning the universal origin of this system. These parts are animals and vegetables. The world plainly resembles more an animal or a vegetable, than it does a watch or a knitting-loom. Its cause, therefore, it is more probable, resembles the cause of the former. The cause of the former is generation or vegetation. The cause, therefore, of the world, we may infer to be some thing similar or analogous to generation or vegetation" (78).

22 Kant sought to limit the scope of the design argument, but did not reject it wholesale. Though he rejected the argument as proof of the transcendent and omnipotent God of Judeo-Christian theology, he still accepted that it could establish the reality of a powerful and intelligent author of the world. In his words, "Physical-theological argument can indeed lead us to the point of admiring the greatness, wisdom, power, etc., of the Author of the world, but can take us no further" (Kant, *The Critique of Pure Reason*, *The Critique of Practical Reason and Other Ethical Treatises*, *The Critique of Judgement*, 523).

23 Reid, *Lectures on Natural Theology*, 59.

24 Paine, *The Age of Reason*, 6.

25 Paley, *Natural Theology*, 8–9. For a different view that challenges the idea that Darwin decisively refuted Paley, see Shapiro, "Myth 8." For additional discussion of the status of the design argument during this period, see Chapter 3, n. b, at www.returnofthegodhypothesis.com/extendedresearchnotes.

26 Paley, *Natural Theology*, 8–9.

27 Bridgewater, *The Bridgewater Treatises.*

28 Adam Shapiro takes an even more sanguine view of the durability of the design argument, pointing out that Darwin did not answer all the questions that motivated Paley's case for design in his *Natural Theology* ("Myth 8").

29 Darwin, *On the Origin of Species* (1964), 453.

30 Laplace, *The System of the World*, 354–75.

31 Laplace, *The System of the World*, 354–75.

32 Quoted in Kaiser, *Creation and the History of Science*, 267.

33 For a more extensive discussion of the factual status of this incident, see Kaiser, *Creation and the History of Science*, 267. See also Chapter 3, n. c, at www.returnofthegodhypothesis.com/extendedresearchnotes.

34 For a more extensive discussion of the factual status of this report, see Chapter 3, n. c, at www.returnofthegodhypothesis.com/extendedresearchnotes.

35 Lyell, *Principles of Geology.*

36 Darwin, *On the Origin of Species* (1964), 130–72.

37 Ayala, "Darwin's Revolution," 4.

38 Sire, *The Universe Next Door*, 18.

39 For a discussion of this methodological shift, see Gillespie, *Charles Darwin and the Problem of Creation*, 41–66, 82–108.

40 Gillespie, *Charles Darwin and the Problem of Creation*, 67–81.

41 Gillespie, *Charles Darwin and the Problem of Creation*, 36, 75, and notes therein. See also Agassiz, "The Primitive Diversity and Number of Animals in Geological Times."

42 Darwin, *The Origin of Species* (2003), 414.

43 For a more extensive discussion of the shifting conventions concerning the acceptability of invoking creative intelligence as a scientific explanation during the nineteenth century, see Chapter 3, n. d, at www.returnofthegodhypothesis.com/extendedresearchnotes.

44 Marx discusses the concept of dialectical materialism in various works, but the most notable is *Das Kapital*, in which Marx applied Hegel's concept of dialectical idealism to focus more on the material world (Marx, *Capital*.)

45 Freud's works are numerous, and a full summary is not relevant here. Some important points here, however, are his ideas regarding sexuality, in particular infantile sexuality (see *The Interpretation of Dreams* and *Three Essays on the Theory of Sexuality*), and his model of the human psyche, constituted by the id, ego, and superego (see *Beyond the Pleasure Principle* and *The Ego and the Id*).

46 Some have noted that Marx disliked the label "atheist" and did not apply it to himself, because he regarded people who defined themselves in this way as trying too hard to define themselves in relation to what they did not believe. Nevertheless, he clearly did not believe in God, nor was he merely agnostic in the popular sense. Instead, as a committed dialectical materialist, he rejected any notion of God as a reality and so, as a matter of philosophical categorization, the label clearly applied to him. See Marx and Engels, *Economic and Philosophic Manuscripts of 1844*, 72.

47 Marx, *A Contribution to the Critique of Hegel's Philosophy of Right*.

48 Freud, *The Future of an Illusion*.

49 Draper, *History of the Conflict Between Religion and Science*; White, *A History of the Warfare of Science with Theology in Christendom*.

50 Ayala, "Darwin's Revolution," 4–5.

51 Provine, "Evolution and the Foundation of Ethics."

52 Futuyma, *Evolutionary Biology*.

53 Dawkins, *The Blind Watchmaker*.

54 Simpson, *The Meaning of Evolution*.

55 Simpson, *The Meaning of Evolution*, 344–45.

56 Ayala, "Darwin's Greatest Discovery."

57 See Bingham, "Richard Dawkins"; HuffPost.com. "Bill Nye On Belief In God: Explains How And Why He Is Agnostic (VIDEO)." 1/22/2014. Accessible at: https://www.huffpost.com/entry/bill-nye-on-belief-in-god_n_4645891.

58 See Dawkins, "The Improbability of God."

59 Futuyma, *Evolutionary Biology*, 3.

60 Michael Peterson provides a helpful threefold typology of perceived relationships between science and religion ("*Reason and Religious Belief*," 196–216). Peterson discusses the conflict, compartmentalism, and complementarity models of the interaction between science and religion. He does not, however, consider the possibility that scientific evidence might support theistic belief, though that remains a logical possibility. I have, therefore, proposed (and am defending here) a fourth model called "qualified agreement" or "epistemic support." See Meyer, "The Demarcation of Science and Religion," 18–26. See also Dembski and Meyer, "Fruitful Interchange or Polite Chitchat?"

61 Gould, *Rocks of Ages*.

62 MacKay, *The Clockwork Image*, 51–55; Van Till, *The Fourth Day*, 208–15; Van Till, Young, and Menninga, *Science Held Hostage*, 39–43, 127–68. See Gruenwald, "Science and Religion: The Missing Link," for a different interpretation of complementarity, which affirms the methodological autonomy of science and religion, but conjoins their findings.

63 Pond, "Independence."

64 See Russell, *Michael Faraday: Physics and Faith*.

65 See Guyot, *Memoir of Louis Agassiz: 1807–1873*. I also discuss Agassiz and his work elsewhere (Meyer, *Darwin's Doubt*, 7–25).

66 Indeed, it was Maxwell who insisted on placing the inscription *Magna opera Domini, Exquista in omnes voluntates ejus* on the archway of the Cavendish Laboratory in Cambridge. The inscription, quoting Psalm 111, reads "Great are the works of the Lord, sought out by all who take pleasure therein." See also Hutchinson, "James Clerk Maxwell and the Christian Proposition."

Chapter 4: The Light from Distant Galaxies

1 Dowden, "Time."
2 Aristotle, *Physics* III.
3 Augustine discusses the concept of creation *ex nihilo* in his *Confessions*: "Thus it was that in the beginning, and through thy Wisdom which is from thee and born of thy substance, thou didst create something and that out of nothing" (bk. 12, chap. 7; *Confessions and Enchiridion*, 175).
4 Aquinas, *Summa contra Gentiles* 2:17.
5 Maimonides, *Guide*, 2.13.
6 Bonaventure, *Commentaries on the Sentences of Peter Lombard*, Book II, Distinction 1, Part 1, Article 1, Question 2.
7 Craig, *The Kalām Cosmological Argument*, 1–49.
8 Moreland, *Scaling the Secular City*, 31.
9 See Jonathan Jacobs, "Maimonides (1138–1204)," *Internet Encyclopedia of Philosophy*, ed. James Fieser and Bradley Dowden, https://www.iep.utm.edu/maimonid.
10 For a more extensive discussion of Bonaventure's argument for a finite universe, see Chapter 4, n. a, at www.returnofthegodhypothesis.com/extendedresearchnotes.
11 Harrison, *Darkness at Night*, 15–27.
12 Harrison, *Darkness at Night*, 50–60.
13 For a detailed historical overview, see Jaki, *The Paradox of Olbers' Paradox*.
14 Jaki, *The Paradox of Olbers' Paradox*, 26–28.
15 Perceptive readers will realize that Poe's solution to Olbers's paradox implied that the universe had not only expanded in the past, but that it must have expanded faster than the speed of light. Though Einstein's theory of relativity stipulates that objects within a local frame of reference can move faster than the speed of light, it does not preclude the possibility that space itself might expand faster than the speed of light. And, indeed, astronomers and cosmologists today think that the rapid expansion of space in the early "inflationary" phase of the history of the universe pushed particles of matter away from each other at rates faster than the speed of light by many orders of magnitude.
16 Poe, *Eureka*, 62.
17 For more background on what Poe and astronomers at the time knew about the speed of light, see Chapter 4, n. b, at www.returnofthegodhypothesis.com/extendedresearchnotes.
18 Poe, *Eureka*, 18.
19 Hawking, *A Brief History of Time*, 6.
20 Recall that though Newton believed that the material contents of the universe had been created a finite time ago, he assumed that space extended infinitely far in every direction and time extended infinitely back into the past.
21 Singh, *Big Bang*, 79.
22 Singh, *Big Bang*, 190–94.
23 Astronomers still use the term "nebula" (and "nebulae," plural) to describe any celestial object that looks cloudy, but now recognize that many objects in the night sky that look (or looked) cloudy represent galaxies far beyond the Milky Way.
24 Singh, *Big Bang*, 190–94.
25 For background on how William Herschel laid the foundation for the discovery that our solar system resides in what we now call the Milky Way galaxy, see Chapter 4, n. c, at www.returnofthegodhypothesis.com/extendedresearchnotes.
26 See Hockey, *The Biographical Encyclopedia of Astronomers*.
27 Cepheid variables were so named because the first such variable star was identified as the fourth brightest in the constellation Cepheus. It was called Delta Cephei—"Delta," for the fourth letter in the Greek alphabet. The periods in question for different Cepheids ranged from about one to one hundred days (Johnson, *Miss Leavitt's Stars*, 34–44, esp. 38).

28 Johnson, *Miss Leavitt's Stars*, 38. Leavitt established a precise mathematical relationship between the periods of variation and apparent brightnesses of Cepheids in the Small Magellanic Cloud. Since all the Cepheids in the galaxy that she observed were approximately the same distance from the earth, the observed differences in the apparent brightness of these stars were proportional to the differences in the absolute brightness as well. Leavitt established the relationship between apparent brightness and the period of pulsation by plotting one variable against the other. Her data would also allow astronomers to plot the absolute brightnesses of those stars against their pulsation periods. Since the apparent and absolute brightnesses of these stars *are* proportional, the two lines plotting brightness (absolute or apparent) against period necessarily correspond to each other by a predictable factor. In fact, they are plotted as parallel lines on a logarithmic scale, or what is known as a "log-log" graph. Logarithmic scales are typically used to measure exponential, rather than linear, changes. The units that these scales use to plot change on a graph are powers, or "logarithms," of a base number, often base ten.

29 Singh, *Big Bang*, 206–12.

30 A parsec is defined by reference to a simple trigonometric formula. One parsec equals the distance at which one astronomical unit of perpendicular motion relative to an observer generates an angular displacement of one arcsecond, which corresponds to $648000/\pi$ astronomical units (where an astronomical unit is 93,000,000 miles, the distance from the earth to the sun).

31 Dust in the galactic plane can reduce apparent brightness and introduce a complicating factor in calculating absolute brightness and distance to Cepheid stars from apparent brightness. Astronomers have attempted to develop methods for compensating for this problem in their calculations but have not yet developed methods that do so entirely reliably (Mandel et al., "The Type Ia Supernova Color–Magnitude Relation and Host Galaxy Dust").

32 Leavitt did not know the factor for converting apparent to absolute brightness, or what astronomers call the "zero point constant." Astronomers report apparent and absolute brightness in magnitudes. Magnitudes are measured with a logarithmic scale rather than a linear scale. Consequently, astronomers talk about the "zero point," which refers to the additive term in a magnitude equation using a logarithmic measure of apparent brightness.

33 For a more extensive discussion of parallax-based methods of measuring astronomical distances, including Hertzsprung's statistical parallax method, see Chapter 4, n. d, at www.returnofthegodhypothesis.com/extendedresearchnotes.

34 For just a bit more on how Hertzsprung used statistical parallax and how he also built on Henrietta Leavitt's results, see Chapter 4, n. e, at www.returnofthegodhypothesis.com/extendedresearchnotes.

35 Technically, Hertzsprung used Leavitt's graph plotting the *logarithm* of the period of pulsation against the *logarithm* of the apparent brightness of Cepheids in the Small Magellanic Cloud. He did this in the process of determining the apparent brightness of a star in the Small Magellanic Cloud with the same period of pulsation as the average of the *logarithm* of the Cepheid variables of the group near the sun.

36 Recall Leavitt's graph plotted the period of pulsation versus the apparent brightness, and the period of pulsation versus the absolute brightness, of Cepheids in the Small Magellanic Cloud.

37 Hearnshaw, *The Measurement of Starlight*, 349.

38 Johnson, *Miss Leavitt's Stars*, 55.

39 Fernie, "The Period-Luminosity Relation."

40 See "Hubble's Famous M31 VAR! Plate."

41 The actual distance to the Andromeda galaxy as determined by the most current astronomical measurements is 2,500,000 light-years. Virginia Trimble documents the long sequence of errors in calculation that led to the underestimation of that distance ("Extragalactic Distance Scales").

42 The emission and absorption lines and the spacing and relative intensity of these lines are plotted as a function of wavelength.
43 For an amplifying discussion of how astronomers use spectral lines and spectroscopy more generally to study objects in the night sky, see Chapter 4, n. f, at www.returnofthegodhypothesis.com/extendedresearchnotes.
44 Trimble, "Anybody but Hubble!"
45 Singh, *Big Bang*, 247–49.
46 Trimble, "H_0: The Incredible Shrinking Constant."
47 Oddly, Hubble may have never believed the obvious implication of his observations—that the universe was expanding (Sandage, "Edwin Hubble 1889–1953"). In addition, as we'll see in the next chapter, the Belgian astronomer Georges Lemaître had discovered the existence of a linear relationship between recessional velocity and distance two years earlier, though he published his conclusion in less prominent scientific publications.
48 It's important to note that there are gravitational effects that swamp the distancing effect of the expansion rate of the universe. These are called "peculiar motions." Thus, for instance, due to the close proximity of the Andromeda galaxy to us, the Milky Way and Andromeda are approaching each other. Consequently, light coming from a few nearby galaxies exhibits a Doppler blueshift, even if the vast majority of galaxies show a red shift.
49 Hubble, "A Relation Between Distance and Radial Velocity Among Extra-Galactic Nebulae."
50 The age of the universe approximates the inverse of the Hubble constant (Liddle, *An Introduction to Modern Cosmology*, 61–66).
51 Science writer Fred Heeren has a nice explanation of how an expanding balloon illustrates the uniform expansion of the universe; see *Show Me God*, 152.

Chapter 5: The Big Bang Theory

1 Einstein, "Die Feldgleichungen der Gravitation"; "Die Grundlage der allgemeinen Relativitätstheorie." The English translation is in Lorentz et al., *The Principle of Relativity*, 109–64; Chaisson and McMillan, *Astronomy Today*, 604–5.
2 Krane, *Modern Physics*, 31–43.
3 Singh, *Big Bang*, 109–16.
4 Krane, *Modern Physics*, 486–92.
5 As quoted in Sutton, "Review of *Einstein's Universe*."
6 Eddington, "The Deflection of Light During a Solar Eclipse."
7 Harrison, *Darkness at Night*, 73. Even so, Newton's proposed homogeneous distribution of mass solution didn't really solve the problem. The hypothetical universe that he described would have itself been vulnerable to the emergence of any slight "lumpiness" or inhomogeneity. Theoretically, an ant's sneeze would have caused an imbalance in the equipoised gravitational forces, causing the whole system to congeal.
8 Einstein, "Kosmologische Betrachtungen zur allgemeinen Relativitätstheorie."
9 In this paper he argued that his equations allowed for a static universe if two assumptions held, namely, (1) that the curvature of space was positive (like the surface of a sphere) and (2) that the field equations included an additional term known as the cosmological constant (with a precisely calibrated value). For a historical overview, see O'Raifeartaigh, "Einstein's Greatest Blunder?"
10 Einstein's field equations as applied to cosmology represent the volume and curvature of the space in the universe at a given time as a function of the mass-energy density within space. According to Einstein's theory, the mass-energy of the universe always tends to curve space in on itself. Consequently, if gravity were the only force at work in the universe, the mass-energy of the universe would eventually cause space to collapse.

Thus, to account for the existence of the space in our universe, Einstein needed to invoke something else that could plausibly counteract the force of gravitational contraction due to the mass-energy in the universe. To do this, Einstein proposed his cosmological constant to represent the energy *inherent in space itself*—energy that causes space itself to expand. In order to depict a static—neither expanding nor contracting—universe, he further assigned an extremely precise value to this negative vacuum energy, so as to balance its repulsive force precisely against the gravitational attraction produced by the mass-energy contained in space.

11 Though the *value* for the cosmological constant that he chose was arbitrary in the sense of being unmotivated by any physical consideration other than his assumption that the universe must be static, the constant itself did appear naturally in the derivation of the field equations as a constant of integration.

12 In the field equations of general relativity, the radius of the universe (or the radius of curvature) is sometimes represented with a term called "the scale factor." The scale factor provides a measure of the radius of the universe relative to (or in proportion to) the universe's current radius.

13 Einstein expressed this assumption mathematically by setting the derivatives of density and radius (i.e., the rate of change of density and the rate of change of radius) in his field equations to zero.

14 Einstein's assumptions about the radius of curvature (analogous to the radius of a sphere) and the mass density of the universe functioned as what physicists call "initial conditions" in his equations. In physics, an initial condition specifies the value of a variable term at some point in the past deemed as the starting point in the mathematical analysis of some physical process. Typically, physicists need to know initial conditions to determine the value of variable terms in the future. Though Einstein's static universe rejected a beginning to the universe, his assumption that neither the density nor the radius of the universe had changed over time allowed him to assign specific values to these (otherwise) variable terms for all times in the past. In particular, Einstein stipulated that the universe would have had the same radius of curvature and density at any time in the past as it has now.

15 Singh, *Big Bang*, 116–43.

16 Nussbaumer, "Einstein's Conversion from His Static to an Expanding Universe."

17 Even with the precise value of the cosmological constant that Einstein had chosen, Einstein's equations—like Newton's—implied an unstable universe, subject to the slightest perturbations (and resulting inhomogeneities) in the distribution of matter. Yet such perturbations would almost certainly occur in a universe of infinite duration.

18 Luminet, "The Rise of Big Bang Models, from Myth to Theory and Observations."

19 Hawking, *A Brief History of Time*, 49. See also Friedmann, "On the Curvature of Space." Hawking actually used these words to describe Friedmann's model of the universe, but his description is more accurate of Lemaître's, since Friedmann did not attempt to decide which model of the universe he thought actually best described its origin. Hawking's description of the early universe as converging on a singularity also makes more sense written after, as it was, his own proofs of various singularity theorems in the late 1960s and early 1970s (see Chapter 6). Before that, many cosmologists entertained the idea that the universe in the distant past could have "necked down" or compressed into a small but finite volume rather than ultimately beginning from a true spatial singularity (Hawking and Ellis, "The Cosmic Black-Body Radiation and the Existence of Singularities in Our Universe"; see also Hawking, "Properties of Expanding Universes," 105; Hawking and Penrose, "The Singularities of Gravitational Collapse and Cosmology"; Hawking and Ellis, *The Large Scale Structure of Space-Time*).

20 For an excellent discussion of some of this history, see Farrell, *The Day Without Yesterday*.

21 Einstein, "Note on the Work of A. Friedmann 'On the Curvature of Space'" (1922), cited in Luminet, "Lemaître's Big Bang," n. 4.

22 Einstein, "Note on the Work of A. Friedmann 'On the Curvature of Space'" (1923), cited in Luminet, "Lemaître's Big Bang," n. 5.
23 The Solvay conference was sponsored by the International Solvay Institutes for Physics and Chemistry.
24 Nussbaumer, "Einstein's Conversion from His Static to an Expanding Universe," 4. R. W. Smith, "E. P. Hubble and The Transformation of Cosmology," 57.
25 Luminet, "Lemaître's Big Bang," 10.
26 Douglas, "Forty Minutes with Einstein."
27 Nussbaumer, "Einstein's Conversion from His Static to an Expanding Universe," esp. 4–6. See also Douglas, "Forty Minutes with Einstein."
28 Nussbaumer, "Einstein's Conversion from His Static to an Expanding Universe," 5. For an extended quotation from Eddington describing why he came to the conclusion that Einstein's static universe was unstable, see Chapter 5, n. a, at www.returnofthgod hypothesis.com/extendedresearchnotes.
29 "Prof. Einstein Begins His Work at Mt. Wilson"; actual quote: "New observations by Hubble and Humason concerning the red shift of light in distant nebulae make it appear likely that the general structure of the Universe is not static."
30 "Redshift of Nebulae a Puzzle, Says Einstein," referenced in O'Raifeartaigh and McCann, "Einstein's Cosmic Model of 1931 Revisited."
31 Luminet, "Lemaître's Big Bang," 10.
32 Dicke et al., "Cosmic Black-Body Radiation," 415.
33 Kragh, *Cosmology and Controversy*, 179–87.
34 Bondi and Gold, "The Steady-State Theory of the Expanding Universe"; Hoyle, "A New Model for the Expanding Universe."
35 Singh, *Big Bang*, 343.
36 Luminet, "Lemaître's Big Bang," 2. In fairness, Hoyle's creation field was no more ad hoc than Einstein's cosmological constant. To see why, see Chapter 5, n. b, at www.return ofthegodhypothesis.com/extendedresearchnotes.
37 The age of the solar system has been estimated by dating the age of meteorites that have fallen to earth. See Singer, "The Origin and Age of the Meteorites."
38 Kragh, *Cosmology and Controversy*, 79.
39 Singh, *Big Bang*, 283–85; See also: Gamow, George. "Expanding Universe and the Origin of the Elements." *Physical Review* 70 (1946): 572–73.
40 Singh, *Big Bang*, 333.
41 Kragh, *Cosmology and Controversy*, 132–35.
42 Liddle, *An Introduction to Modern Cosmology*, 13–16.
43 Singh, *Big Bang*, 376–83.
44 Baade, "Problems in the Determination of the Distance of Galaxies," 207.
45 Sandage, "Current Problems in the Extragalactic Distance Scale."
46 Planck Collaboration, "Planck 2015 Results."
47 Kragh, *Cosmology and Controversy*, 299–305. See also Burbidge et al., "Synthesis of the Elements in Stars," 547.
48 It is important to note that elements heavier than iron aren't made by the fusion of two nuclei, but instead by neutron capture in supernovae or, as has been more recently argued, by neutron star disruption in merging binary stars. See Wallerstein et al., "Synthesis of the Elements in Stars: Forty Years of Progress."
49 Singh, *Big Bang*, 422–35.
50 Penzias and Wilson, "A Measurement of Excess Antenna Temperature at 4080 Mc/s."
51 Alpher, "Ralph A. Alpher, George Antonovich Gamow, and the Prediction of the Cosmic Microwave Background Radiation," 17–26.
52 Singh, *Big Bang*, 440; Kragh, "The Steady State Theory," 403. For an excellent history of the steady-state theory, see also http://www.astro.ucla.edu/~wright/stdystat.htm.
53 Guth and Sher, "The Impossibility of a Bouncing Universe," 505–7. More recent

oscillating universe models have been proposed by such physicists as Paul Steinhardt and Paul Frampton. These models commonly assert that the expansion of the universe was preceded by a contraction phase and then a bounce that initiated the subsequent expansion. These models posit that during the contraction phase the patch of space corresponding to our visible universe experienced a smoothing process that explains the observed homogeneity and isotropy ("Big Bounce Simulations Challenge the Big Bang | Quanta Magazine," accessed October 9, 2020, https://www.quantamagazine.org/big-bounce-simulations-challenge-the-big-bang-20200804/). The models that allow for an eternal universe with infinite cycles then also invoke mechanisms that would reset the entropy to an extremely low value after each cycle. Nevertheless, no evidence for such exotic mechanisms has ever been discovered (or likely could be). In addition, even the models that simply describe a single bounce face significant theoretical challenges such as instabilities resulting from the bounce violating the null energy condition (Diana Battefeld and Patrick Peter, "A Critical Review of Classical Bouncing Cosmologies," *Physics Reports* (Elsevier B.V., April 1, 2015)).

54 "What Is the Ultimate Fate of the Universe?" *National Aeronautics and Space Administration*, June 29, 2015, https://map.gsfc.nasa.gov/universe/uni_fate.html.

55 A significant minority of astronomers contest the idea that the universe is accelerating in its expansion. See, e.g., Billings, "Cosmic Conflict."

56 Peebles and Ratra, "The Cosmological Constant and Dark Energy."

57 Luminet, "Dodecahedral Space Topology as an Explanation for Weak Wide-Angle Temperature Correlations in the Cosmic Microwave Background."

58 The quote is from 1992 press conference. See Krehl, *History of Shock Waves, Explosions and Impact*, 787.

59 Though Sandage did confirm the linear relationship between the rate of galactic recession and distance, he did, as noted above, also recalibrate distance measurements to many of those galaxies.

60 Allan Sandage quotes are from my own transcript of a private film of Sandage's remarks at "Christianity Challenges the University: An International Conference of Theists and Atheists," Dallas, Texas, February 7–10, 1985. See also Sandage, "A Scientist Reflects on Religious Belief."

61 Willford, "Sizing up the Cosmos."

62 My transcript of Allan Sandage's remarks; see n. 60. See also Sandage, "A Scientist Reflects on Religious Belief."

63 Gingerich, "Scientific Cosmology Meets Western Theology"; Meyer, "Owen Gingerich."

64 Jastrow, *God and the Astronomers*, 116.

Chapter 6: The Curvature of Space and the Beginning of the Universe

1 Here's the full (unsimplified) quotation: "Therefore, by equations 1 and 5, any time-like or null irrotational geodesic must have a singular point on each geodesic within a finite affine distance. If the flow lines form an irrotational geodesic congruence, there will be a physical singularity at the physical points of the congruence, where the density and hence the curvature are infinite" (Hawking, "Properties of Expanding Universes," 105).

2 Hawking and Penrose, "The Singularities of Gravitational Collapse and Cosmology."

3 Hawking and Ellis, *The Large Scale Structure of Space-Time*.

4 Hawking and Penrose, "The Singularities of Gravitational Collapse and Cosmology."

5 Luminet, "The Rise of Big Bang Models," 2.

6 As Senovilla and Garfinkle comment: "Of course, this singular behaviour could be due to an excess of symmetry (spherical) [i.e., homogeneity], which, as exact, would not be realistic. Very remarkably he gave up spherical symmetry and studied the spatially

homogeneous but anisotropic models that today we call Bianchi I models. The conclusion was unambiguous: the singularity is still there, 'anisotropy can no more prevent the vanishing of space'" ("The 1965 Penrose Singularity Theorem").

7 Friedmann's and Lemaître's assumption of homogeneity has proved to be a relatively accurate description of the universe today (especially when comparing the density of large volumes of space in different quadrants of the universe); it did prove an inaccurate assumption about the universe in its earliest stages of development. Thus, their assumption of homogeneity cast doubt on extrapolations (based upon their mathematical models) back to the beginning of the universe.

8 Hawking and Ellis, *The Large Scale Structure of Space-Time*, 6; Luminet, "The Rise of Big Bang Models."

9 Confirmed in a personal interview with George Ellis, Cap Estel, France, June 12, 2018.

10 Lemaître did eventually consider solutions to the field equations with nonhomogeneous distributions of matter, but his work did not have the mathematical rigor of that of Hawking, Penrose, and Ellis as expressed in their later proofs of the singularity.

11 Hawking and Ellis, *The Large Scale Structure of Space-Time*, 6; see also their discussion on 261–62.

12 Hawking and Ellis, *The Large Scale Structure of Space-Time*, 261–62.

13 Hawking and Ellis, *The Large Scale Structure of Space-Time*, xi.

14 Hawking and Ellis, *The Large Scale Structure of Space-Time*, 8.

15 Hawking and Ellis, *The Large Scale Structure of Space-Time*, 78.

16 In particular, they argued unless there are singularities, "focal points" would emerge on the time-like and light-like lines of trajectory (what they called "longest curves") that would deny the finite nature of these light/time-like lines ("longest curves") back into the past. Focal points allow light rays to travel through them and to continue traveling indefinitely (and thus infinitely far back into the past). But this result would contradict the proof that they had already established of the incompleteness of the time-like geodesics. Thus, it follows that there must have been a spacetime singularity in the past.

17 Hawking and Ellis, *The Large Scale Structure of Space-Time*, 256.

18 Davies, "Spacetime Singularities in Cosmology," 78–79.

19 Hawking and Ellis, *The Large Scale Structure of Space-Time*, 364.

20 Ross, *The Creator and the Cosmos*, 66–67; Vessot et al., "Test of Relativistic Gravitation with a Space-Borne Hydrogen Maser," 2081–84.

21 Today most physicists think that quantum gravitational effects would begin to manifest themselves inside the so-called Planck length of 10^{-35} of a meter corresponding to the so-called Planck time of 10^{-43} of a second after the big bang.

22 For more technical definition of these various energy conditions, see Chapter 6, n. a, at www.returnofthegodhypothesis.com/extendedresearchnotes. Most important, see also Hawking and Ellis, *The Large Scale Structure of Space-Time*, 88–96; Curiel, "A Primer on Energy Conditions."

23 Hawking and Penrose, "The Singularities of Gravitational Collapse and Cosmology," 529, 531. (Recall that Hawking and Penrose just call this strong energy condition "the energy condition.") See also Hawking and Ellis, *The Large Scale Structure of Space-Time*, 95–96. Physicist Frank Tipler has argued that the strong energy condition can be replaced by the weak energy condition if the strong energy condition holds on average ("Energy Conditions and Spacetime Singularities").

24 Hawking and Ellis, *The Large Scale Structure of Space-Time*, 96, 363.

25 Guth, "Inflationary Universe." See also Linde, "A New Inflationary Universe Scenario"; Albrecht and Steinhardt, "Cosmology for Grand Unified Theories with Radiatively Induced Symmetry Breaking." In Guth's original model he proposed that the rapid initial expansion of space was generated by what he called an "inflationary field" that he equated with the "Higgs field." Later proponents of eternal chaotic inflation refer more generically to the field responsible for the early rapid outward expansion of space as an

"inflaton field." They do not associate it, as Guth did his inflationary field, with the Higgs field—the field that is responsible for giving particles their masses according to the standard model of particle physics.

26 Linde, "Eternally Existing Self-Reproducing Chaotic Inflationary Universe."

27 Borde and Vilenkin, "Violation of the Weak Energy Condition in Inflating Spacetimes."

28 Personal interview with George Ellis, Cap Estel, France, June 12, 2018.

29 Guth, "Eternal Inflation and Its Implications."

30 Liddle, *An Introduction to Modern Cosmology*, 80–82.

31 Perfect flatness is only possible if the universe exhibits both critical mass density and perfect homogeneity.

32 Note that in my description of the expansion of the universe at this point in its history, I have begun to focus on mass rather than mass-energy. That's because between about 50,000 and 100,000 years after the beginning of the universe, mass rather than radiation begins to dominate the dynamics and geometry of the universe. See Carroll and Ostlie, *An Introduction to Modern Astrophysics*, 1194. In the distant future dark energy will become the dominant factor. See Frieman, Turner, and Huterer, "Dark Energy and the Accelerating Universe."

33 The curvature of space can be estimated based on certain observed gravitational effects.

34 Inflation also explains the range and distribution of the wavelengths in the cosmic background radiation, though a discussion of how it does so would require too much explanation given the scope and focus of this chapter.

35 For a discussion of the earlier papers by Borde and Vilenkin that concluded, first (in 1994), that inflationary cosmology *could not* and, then (in 1997), that it *could* avoid an initial singularity, see Chapter 6, n. b, at www.returnofthegodhypothesis.com/extendedresearchnotes.

36 Borde, Guth, and Vilenkin, "Inflationary Spacetimes Are Incomplete in Past Directions."

37 Vilenkin, *Many Worlds in One*, 175.

38 Regions of space far apart will recede away from each other with a recession velocity (V_{space}) proportional to the separation distance (d). The constant of proportionality is the Hubble constant (H), which yields the equation $V_{space} = Hd$. Moreover, the observed velocity (V_{ob}) is equal to the velocity of the object, such as a ship (V_{ship}) with respect to the surrounding space minus the recession velocity of that region of space: $V_{ob} = V_{ship} - V_{space}$. I am indebted to Robert J. Spitzer, SJ, for this excellent illustration of the Borde-Guth-Vilenkin theorem. Spitzer, "Evidence for God from Physics and Philosophy," 13–15.

39 As Borde, Guth, and Vilenkin explain in more technical language: "Our argument shows that null and time-like geodesics are, in general, *past-incomplete in inflationary models*, whether or not energy conditions hold, provided only that the averaged expansion condition $H_{av} > 0$ holds along these past-directed geodesics. This is a stronger conclusion than the one arrived at in previous work." ("Inflationary Spacetimes Are Incomplete in Past Directions," 3–4, emphasis added).

40 As Borde, Guth, and Vilenkin summarize the implications of the BGV theorem for the inflationary string landscape multiverse model: "Our argument can be straightforwardly extended to cosmology in higher dimensions. For example, . . . brane worlds are created in collisions of bubbles nucleating in *an inflating higher-dimensional bulk spacetime*. Our analysis implies that the inflating bulk cannot be past-complete" ("Inflationary Spacetimes Are Incomplete in Past Directions," 4, emphasis added).

41 The only proposed cosmologies that avoid the BGV theorem entail physically unrealistic features. For a discussion of these unrealistic cosmologies, see Chapter 6, n. c, at www.returnofthegodhypothesis.com/extendedresearchnotes.

42 Vilenkin, *Many Worlds in One*, 176. See also: Vilenkin, "The Beginning of the Universe"; Grossman, "Why Physicists Can't Avoid a Creation Event," 7. In response, cosmologists now look to quantum cosmological models to describe or explain the beginning of the universe from nothing. As Vilenkin indicates: "What can lie beyond this boundary? Several possibilities have been discussed, one being that the boundary of the inflating

region corresponds to the beginning of the Universe in a quantum nucleation event" (Borde, Guth, and Vilenkin, "Inflationary Spacetimes Are Incomplete in Past Directions," 4). I will critique and evaluate the implications of these proposals in Chapters 17–19.

43 Guth, "Inflation," 19 (pdf).

44 Guth, "Inflation," 19 (pdf).

Chapter 7: The Goldilocks Universe

1 Hoyle, "The Expanding Universe."

2 Hoyle, "The Expanding Universe."

3 Harvard astrophysicist Owen Gingerich commented, "I am told that Fred Hoyle said that nothing shook his atheism as much as this discovery" (*God's Universe*, 57).

4 Other parameters require "one-sided" fine tuning. One-sided fine-tuning parameters impose a single condition on the existence of life by ensuring that life can only exist if the parameter in question has a value either greater than or less than some particular threshold. Often in these cases of one-sided fine tuning the value of the parameter in question falls just near the edge of the life-permitting region.

5 In addition to the values of constants within the laws of physics, the fundamental laws themselves have specific mathematical and logical structures that could have been otherwise—that is, the laws themselves have contingent rather than logically necessary features. Yet the existence of life in the universe depends on the fundamental laws of nature having the precise mathematical structures that they do. For example, both Newton's universal law of gravitation and Coulomb's law of electrostatic attraction describe forces that diminish with the square of the distance. Nevertheless, without violating any logical principle or more fundamental law of physics, these forces could have diminished with the cube (or higher exponent) of the distance. That would have made the forces they describe too weak to allow for the possibility of life in the universe. Conversely, these forces might just as well have diminished in a strictly linear way. That would have made them too strong to allow for life in the universe. Moreover, life depends upon the existence of various different kinds of forces—which we describe with different kinds of laws—acting in concert. For example, life in the universe requires: (1) a long-range attractive force (such as gravity) that can cause galaxies, stars, and planetary systems to congeal from chemical elements in order to provide stable platforms for life; (2) a force such as the electromagnetic force to make possible chemical reactions and energy transmission through a vacuum; (3) a force such as the strong nuclear force operating at short distances to bind the nuclei of atoms together and overcome repulsive electrostatic forces; (4) the quantization of energy to make possible the formation of stable atoms and thus life; (5) the operation of a principle in the physical world such as the Pauli exclusion principle that (a) enables complex material structures to form and yet (b) limits the atomic weight of elements (by limiting the number of neutrons in the lowest nuclear shell). Thus, the forces at work in the universe itself (and the mathematical laws of physics describing them) display a fine tuning that requires explanation. Yet, clearly, no *physical* explanation of this structure is possible, because it is precisely physics (and its most fundamental laws) that manifests this structure and requires explanation. Indeed, clearly physics does not explain itself. See Gordon, "Divine Action and the World of Science," esp. 258–59; Collins, "The Fine-Tuning Evidence Is Convincing," esp. 36–38.

6 Denton, *Nature's Destiny*, 101–16.

7 Dicke, "Dirac's Cosmology and Mach's Principle."

8 Some might object to the wording of this statement, since elements on the periodic table are defined not by the number of neutrons they have but by the number of protons. Nevertheless, since new elements cannot be built without neutrons (as well as protons)

for stability, it is entirely correct to think of building new elements one proton or neutron at a time. Even so, new elements cannot be built just by adding new neutrons (or protons). Indeed, new elements need both types of nucleons, even if different isotopes of those elements exist with different numbers of neutrons.

9 Alpher, Bethe, and Gamow, "The Origin of Chemical Elements."

10 Singh, *Big Bang*, 323–25.

11 Hoyle actually calculated the differences in *mass* between the beryllium and the helium combined, on the one hand, and the mass of known carbon atoms, on the other. That difference between the two also constituted—by Einstein's energy-to-mass conversion equation of $E = mc^2$—a calculable difference in energy. As Simon Singh notes, "The combined mass of a helium nucleus and a beryllium nucleus is very slightly greater than the mass of a carbon nucleus, so if they did fuse to form carbon then there would be the problem of getting rid of the excess mass. Normally nuclear reactions can dissipate any excess mass by converting it into energy [in accord with $E = mc^2$], but the greater the mass difference, the longer the time required for the reaction to happen. And time is something the beryllium-8 nucleus does not have" (Singh, *Big Bang*, 392–93). Consequently, Hoyle had to propose a state of carbon with an energy excitation level of exactly the right magnitude to make possible the immediate fusion of the beryllium and the helium within the time dictated by the beryllium half-life.

12 Lewis and Barnes, *A Fortunate Universe*, 113–20.

13 In addition, life in the universe depends upon roughly comparable abundances of carbon and oxygen. Had this energy level in oxygen (at 7.1 MeV) been just a little higher, most of the carbon would be consumed to make oxygen inside stars. Yet both carbon and oxygen are required for life in comparable amounts. See Denton, *Nature's Destiny*, 11–12.

14 Burbidge et al., "Synthesis of the Elements in Stars."

15 Csoto, Oberhummer, and Schlattl, "Fine-Tuning the Basic Forces of Nature Through the Triple-Alpha Process in Red Giant Stars," 560. Epelbaum et al., "Dependence of the Triple-Alpha Process on the Fundamental Constants of Nature." See also Adams and Grohs, "Stellar Helium Burning in Other Universes." Against this, Adams and Grohs have argued that they can explain away the fine tuning of the strong nuclear force. They note that an increase in the strong nuclear force by a small amount (within the range where carbon and oxygen are still produced in comparable amounts) will allow beryllium-8 to be stable. In that case, carbon and oxygen can be produced by two-collision reactions instead of the three-step triple-alpha reaction. Nevertheless, this possibility only eliminates fine tuning on one side. Indeed, even in a two-step reaction, the strong nuclear force cannot be set more than a few percent smaller, even if it can be larger and still allow beryllium production. Moreover, other factors also constrain the value of the SNF on the upper side. For instance, if the SNF were 50 percent larger, the majority of hydrogen would have turned into helium in the early universe, which would have hindered star formation. See MacDonald and Mullan, "Big Bang Nucleosynthesis."

16 Barnes, "The Fine-Tuning of the Universe for Intelligent Life," 548–50.

17 The assumed upper bound for the masses is the Planck mass. The Planck mass is the unit of mass in the system of natural units known as Planck units. The Planck units normalize the speed of light in a vacuum (c), the gravitational constant (G), the reduced Planck constant (ħ), the Coulomb constant (k_e), and the Boltzmann constant (k_B) to 1. The Planck mass is defined as follows: $m_p = \sqrt{\hbar c/G}$. It equals approximately 0.02 milligrams.

18 The mass of the up quark is approximately 1.6×10^{-22} of the Planck mass, and the mass of the down quark is approximately 3.9×10^{-22} of the Planck mass. For the universe to permit life, the up and down quarks must have a mass roughly between 10^{-22} and 10^{-21} times the Planck mass. (S. M. Barr and Almas Khan, "Anthropic Tuning of the Weak Scale and of M_u/M_d in Two-Higgs-Doublet Models," *Phys. Rev. D* 76, no 4: 045002.)

19 In theory, alterations to the gravitational force constant (G) could be partially compensated for by alternations to the process of nucleosynthesis inside stars resulting

from variations in the strength of electromagnetism and the size of the stars in question. But even taking the most extreme case, where nuclear reactions are extremely favorable to stellar burning, stars in universes with larger values of G would burn out much faster than stars in our universe. As physicist Luke Barnes has shown, regardless of the strengths of the forces, all stars of all sizes burn out in less than a million years unless values of G are extremely finely tuned—in particular, G for all stars of all sizes must fall within a range that is less than 1 part in 10^{30} of the value of the strong nuclear force, the upper bound defining the range of expected possible values of G. (Specifically, this case concerns the ratio of the proton mass to the Planck mass, which depends on G.) See Barnes, "Binding the Diproton in Stars." Barr and Khan, "Anthropic Tuning of the Weak Scale and of the Mu/Md in Two-Higgs' Doublet Models.

20 Lewis and Barnes, *A Fortunate Universe*, 108.

21 Lewis and Barnes, *A Fortunate Universe*, 108.

22 Specifically, if gravity were increased by a factor of 3000, stars would be too short-lived for terrestrial planets to develop sufficiently to support complex life. Conversely, if the gravitational force constant were set to zero, neither planetary atmospheres nor planets could exist. This requirement corresponds to two-sided fine tuning of 1 part in ~10^{36} (or $3000/10^{40}$). See Collins, "Evidence for Fine-Tuning," 189–90.

23 In addition, if the gravitational force pulls too weakly, planets would not be able to hold down an atmosphere, making respiration impossible for living organisms. Conversely, if the gravitational force pulls too strongly, planets would retain noxious gases in their atmosphere. Of course, compensatory factors could mitigate the degree of this fine tuning as well. For example, for much smaller planets, gravity could be much larger and not cause the retention of noxious gases in the planetary atmosphere even for a larger G value. Nevertheless, smaller planets are subject to other constraints. Smaller planets have a larger surface area-to-volume ratio, and that leads to more rapid cooling of the planet's interior, making volcanism and plate tectonics impossible—both of which are necessary for life for other reasons. A larger surface area-to-volume ratio and more rapid cooling also lead to a weakened magnetic field, depriving potential life forms on a planet of protection against incoming solar radiation. In addition, a stronger gravitational force constant would have led to *a universe* composed of pure helium. See Lewis and Barnes, *A Fortunate Universe*, 78.

24 It might be possible that gravity could vary over an even larger range, but physicists tend to estimate the expected range more conservatively by defining the "comparison range" to be an actual observed range of the force strengths.

25 The range for the possible values of the constant is set between 0 and 10^{40}G. A universe that can support life must have a gravitation constant less than 10^5G. Therefore, the degree of fine tuning is $10^5G/10^{40}G = 10^5/10^{40} = 1$ in 10^{35}. See Lewis and Barnes, *A Fortunate Universe*, 109. Physicist Sabine Hossenfelder has recently argued that many fine-tuning parameters cannot in fact be quantified [Hossenfelder, "Screams for Explanation: Finetuning and Naturalness in the Foundations of Physics," 1–19]. On this basis, she contests the reality of fine tuning as a feature of nature that has to be explained. To support her claim, she points out that many physicists calculate the degree of fine-tuning associated with different parameters by assuming that all possible values of different physical constants, for example, within a given range are equally probable. She then argues that physicists have no way of knowing whether or not this assumption is true.

Perhaps, she suggests, some universe generating mechanism (see Chapter 16) exists that produces universes with, for example, certain gravitational force constants more frequently than universes with other gravitational force constants. Taking such biasing into account would clearly change the calculated degree of fine tuning (or the probability) associated with any given range of values that correspond to a life-permitting universe. Thus, she argues that the possibility of such biasing in the generation of universes implies that we cannot make accurate assessments of fine tuning—and, therefore, that we cannot be sure that the universe actually is fine tuned for life.

Nevertheless, Hossenfelder's objection has an obvious problem. The allowable ranges of many physical constants and parameters are so incredibly narrow within the vast array of other possible values for those different constants and parameters that any universe generating mechanism capable of favoring the production of those specific and tiny ranges would itself need to be finely tuned in order to produce those values in those ranges with high probability. In other words, her universe generating mechanism would require fine tuning to ensure that biasing that would allow her to explain away fine tuning in our universe.

For a critique of other challenges to the quantifiability of the fine tuning associated with different physical parameters see Chapter 7, n. a., at www.returnofthegodhypothesis.com/extendedresearchnotes.

26 Hoyle was apparently not influenced explicitly by anthropic considerations in predicting the carbon resonance levels in 1953, as many writers have claimed. Instead, as noted above, he predicted the precise resonance levels based on his understanding of what would be necessary to produce carbon and thus to account for its abundance in the universe. Later he realized the anthropic significance of the discovery of the precise value of the resonance level. Indeed, he realized that his discovery implied that the universe had been finely tuned for the production of carbon and thus life. He first made the explicit connection between the finely tuned coincidences necessary for carbon and oxygen production and the presence of life in the universe in his 1965 book *Galaxies, Nuclei, and Quasars*. In it he writes, "The whole balance of the elements of carbon and oxygen is critical not only for the chemistry of living organisms but for the distribution of the planets" (147).

27 Davies, *The Accidental Universe*, 71–73.

28 Carr and Rees, "The Anthropic Principle and the Structure of the Physical World."

29 Hoyle, "The Universe."

30 Lewis and Barnes, *A Fortunate Universe*.

31 Davies, *The Cosmic Blueprint*, 203.

32 Lewis and Barnes, *A Fortunate Universe*, 323, 320.

33 In describing the fine tuning of the laws of physics, physicists may, however, also be describing the fine tuning of the mathematical structures of the laws themselves, not just their constants. See n. 5 above.

34 "The Anthropic Principle," May 18, 1987, Episode 17, Season 23, *Horizon* series, BBC.

35 Hawking, *A Brief History of Time*, 26.

36 Probably ten to twelve out of thirty-one total constants exhibit significant fine tuning.

37 Ekström et al., "Effects of the Variation of Fundamental Constants on Population III Stellar Evolution"; Epelbaum et al., "Dependence of the Triple-Alpha Process on the Fundamental Constants of Nature."

38 Csoto, Oberhummer, and Schlattl, "Fine-Tuning the Basic Forces of Nature Through the Triple-Alpha Process in Red Giant Stars," 560.

39 Rees, "Large Numbers and Ratios in Astrophysics and Cosmology." Also Lewis and Barnes, *A Fortunate Universe*, 78.

40 Davies, *The Accidental Universe*, 71–73.

41 Rees, *Just Six Numbers*, 22.

42 Personal interview with Sir John Polkinghorne, Portland, Oregon, 1992. For more information on Polkinghorne's arguments, see Polkinghorne, *Belief in God in an Age of Science*.

43 Personal interview with Sir Brian Josephson, Yale University, March 2, 1986.

44 David Klinghoffer, "Brian Josephson, Nobel Laureate in Physics, Is '80 Percent' Confident in Intelligent Design," *Evolution News & Science Today*, June 28, 2017, https://evolutionnews.org/2017/06/brian-josephson-nobel-laureate-in-physics-is-80-percent-confident-in-intelligent-design.

45 Personal interview with Henry Margenau, Yale University, March 2, 1986.

46 Greenstein, *The Symbiotic Universe*, 27.

47 Longley, "Focusing on Theism."

Chapter 8: Extreme Fine Tuning—by Design?

1 Bonnie Azab Powell, "'Explore as Much as We Can': Nobel Prize Winner Charles Townes on Evolution, Intelligent Design, and the Meaning of Life," *UC Berkeley NewsCenter*, June 17, 2005, https://www.berkeley.edu/news/media/releases/2005/06/17_townes.shtml.

2 Lewis and Barnes, *A Fortunate Universe*, 120–28.

3 Physicists have debated whether equating entropy with disorder is the best approach to communicating the idea to the general public. Technically, entropy relates to the logarithm of the number of configurations accessible to a given state of a system. Some prefer connecting entropy to the ideas of uncertainty or the Shannon measure of information. Nevertheless, the term "order" is usually associated with a more precise and defined arrangement of entities and, therefore, a smaller number of configurations. Consequently, the connection provides an intuitively accurate picture in the context of the early universe.

4 Calculating the entropy of water also requires knowing the number of possible energy states associated with the water molecules as well as knowing the number of possible configurations of those molecules, that is, their relative positions in relation to one another in space.

5 In fact, physicists don't really know how to count or describe the possible states or configurations of matter and energy that might characterize black holes. Indeed, they can't envision the different configurations of matter, energy, and spacetime inside a black hole as they can when thinking about atoms in a gas. They don't know how to characterize the "microstates" in black holes, since they lack a theory of quantum gravity. Strictly speaking, therefore, physicists use thermodynamic considerations, rather than considerations of statistical mechanics, to justify their conclusion that black holes exhibit high entropy. Since, they argue, black holes are in an equilibrium state, they must also be in a state of maximum entropy. Indeed, although a galaxy could collapse (eventually) into a black hole, a black hole will not spontaneously release all its matter to create a galaxy.

6 Our normal ideas about entropy seem a bit counterintuitive when applied to black holes. In his book *The Road to Reality* Roger Penrose explains why: "Gravitation is somewhat confusing, in relation to entropy, because of its universally attractive nature. We are used to thinking about entropy in terms of an ordinary gas, where having the gas concentrated in small regions represents low entropy . . . and where in the high-entropy state of thermal equilibrium, the gas is spread uniformly. But with gravity, things tend to be the other way about. A uniformly spread system of gravitating bodies would represent relatively low entropy (unless the velocities of the bodies are enormously high and/or the bodies are very small and/or greatly spread out, so that the gravitational contributions become insignificant), whereas high entropy is achieved when the gravitating bodies clump together" (706). See also Carroll, *From Eternity to Here*, 287–314.

7 Penrose, "Time-Asymmetry and Quantum Gravity." See also Penrose, *The Road to Reality*, 757–65; Gordon, "Divine Action and the World of Science," 259–61, 267.

8 Penrose used a formula known as the Bekenstein-Hawking formula to estimate the entropy per elementary particle, or "baryon" (i.e., neutrons and protons), in the universe. Using that formula, he obtained a value of 10^{43} per baryon. Since the visible universe contains 10^{80} baryons, he calculated the total entropy of the universe as 10^{123} (i.e., 10^{43} times 10^{80}). As noted, Penrose assumed this number defined the upper range of possible entropy values for the universe. In physics, entropy measures can be unitless (or tendered in "natural units"). Penrose calculated entropy in this context using natural units. Entropy is determined by taking the logarithm of the number of possible configurations consistent with a given state (or the logarithm of the number of possible "microstates" consistent with a given "macrostate"). For information on the Bekenstein-Hawking

formula, see Sfetsos and Skenderis, "Microscopic Derivation of the Bekenstein-Hawking Entropy Formula for Non-Extremal Black Holes." See also Jacob D. Bekenstein, "Bekenstein-Hawking Entropy," *Scholarpedia*, 2008, http://www.scholarpedia.org/article/Bekenstein-Hawking_entropy.

9 To calculate the entropy of the present universe, he estimated that each galaxy had a black hole of a million solar masses at its center, which yields a value of 10^{21} natural entropy units per baryon. By multiplying 10^{21} by 10^{80} baryons (the total number in the universe) he calculated a total entropy for the present universe of 10^{101} natural entropy units. He then assumed that the early universe would have an entropy no greater than that of the present universe.

10 Entropy is proportional to the logarithm of the number of possible configurations of particles for a given state. Physicists refer to the number of such possible configurations as the "phase space volume." Moreover, mathematically, the number of configurations equals 10 to the power of the entropy. Penrose used the logarithmic relationship between number of configurations and entropy to calculate the probability of a universe having an entropy as low as ours. To do that he computed the number of configurations from the entropy value of the universe. This calculation yielded a number of configurations (or a phase space volume, V_o) consistent with how the universe could have started of 10 to the power of 10^{123}. Similarly, the number of configurations or phase space volume associated with the actual early universe, V_a, equates to 10 to the power of 10^{101}. The precision associated with the choice of the early conditions for the universe is then the number of configurations associated with the entropy of the early universe divided by the total number that could have been possible. This value is the ratio of the phase space volumes (V_a/V_o), which approximates to 1 in 10 to the power of 10^{123}. The smaller exponent is, again, swallowed up by the massively larger one. See also Penrose, *Emperor's New Mind*, 444–45.

11 It turns out the initial entropy of our universe was even lower than is necessary to allow the universe to sustain life. Oddly, however, this extremely and extravagantly low initial entropy has made possible extensive astronomical observation and investigation of the universe. In theory at least, we could have lived in a universe in which only our local galactic environment exhibited such low entropy. The rest of the universe could have been characterized by high entropy, which, as noted, corresponds to vast spaces filled with black holes. In that case, life would have been possible in the local galactic environment, but nowhere else. Nevertheless, in our visible universe the whole of space exhibits low-entropy conditions just like those in our local galaxy. Indeed, the rest of the visible universe contains over 100 billion highly ordered (low-entropy) galaxies. Since the rest of the universe is not dominated by black holes, we can observe and investigate it and learn about its history by observing other galaxies and stars beyond our Milky Way. (I'm indebted to my colleague Brian Miller for this insight.)

Guillermo Gonzalez and Jay Richards developed a similar insight concerning our local planetary system in their book *The Privileged Planet*. They argue that the earth was intelligently designed not only to host intelligent life, but also to serve as a platform from which to observe the broader universe. They note, for example, that the earth's geological processes provide us with the basic materials to do science and that its transparent atmosphere allows us to study the planets, stars, and galaxies. In a similar way, the more of the universe we can observe, the better we can determine its properties, structure, and history, and the extremely low entropy of the universe as a whole allows us to do just that. Thus, the way the universe is extravagantly finely tuned beyond what is necessary for life suggests a universe designed for discovery. In support of this conclusion, physicist Brian Miller, a colleague of mine at Discovery Institute, has estimated the degree of entropy fine tuning needed for life to exist in just our low-entropy galaxy as 1 part in $10^{10^{98}}$ as opposed to the fine tuning that would be necessary (1 part in $10^{10^{123}}$) to have low-entropy galaxies suffused throughout the cosmos. The difference in these two measures of fine tuning represents the extent to which the universe is fine-tuned beyond what is necessary just for life to exist and for, arguably, scientific discovery of the cosmos. For a detailed discussion of how Miller made this estimate, see Chapter 8, n. a, at www.returnofthegod hypothesis.com/extendedresearchnotes.

12 For an extended quotation from Davies on this point, see Chapter 8, n. b, at www .returnofthegodhypothesis.com/extendedresearchnotes. See also Schaefer, *Science and Christianity*, 31; Penrose, *The Road to Reality*, 728–30, 762–64; Lewis and Barnes, *A Fortunate Universe*, 125–26, 318–19.

13 Douglas Ell nicely illustrates how absurdly small Penrose's probability is in *Counting to God*, 79–81.

14 Bruce Gordon notes: "Two proposals have been suggested by way of trying to mitigate this entropic fine tuning: (1) the inflationary multiverse overcomes the probabilistic obstacles; and (2) there is some special law that requires a perfectly uniform gravitational field at the beginning of time, thus giving rise to maximally low entropy" ("Divine Action and the World of Science," 261). Nevertheless, he shows that neither of these proposals solves the problem. In the first place, he notes: "The inflationary multiverse proposal has massive fine-tuning problems of its own, as well as creating conditions that undermine the very possibility of scientific rationality" (261). In Chapters 16 and 19 of this book, I show why this is the case in detail. Gordon also notes: "The second proposal, that there is a special law requiring a perfectly uniform gravitational field . . . merely shifts the locus of fine tuning from the big bang itself to the gravitational field associated with it." Moreover, he notes that this proposal has been "unpopular among naturalistically minded physicists for a different reason: it requires a genuine singularity at the beginning of time at which all the laws of physics break down" (261).

15 Davies, *Superforce*, 184.

16 For quantitative estimates of the fine tuning of the expansion rate, see Hawking, *A Brief History of Time*, 125. Hawking states that the expansion could not have been smaller by 1 part in 10^{17}, but he does not quantify how much larger the expansion rate could have been without precluding a life-friendly universe. As he stated, "Why did the universe start out with so nearly the critical rate of expansion that separates models that recollapse from those that go on expanding forever, that even now, ten thousand million years later, it is still expanding at nearly the critical rate? If the rate of expansion one second after the big bang had been smaller by even one part in a hundred thousand million million [10^{17}], the universe would have recollapsed before it ever reached its present size." Meanwhile, Paul Davies affirms a two-sided fine tuning of the expansion rate of 1 part in 10^{18} (*Superforce*, 184).

17 The precise value of these different physical factors varies depending upon which of several contending inflationary cosmological models physicists decide to affirm. Since presently physicists do not agree on a standard inflationary model, it's difficult to know whether each of these physical factors are in fact independently finely tuned, though it looks likely that at least some are, again depending upon the model in question. Luke Barnes has argued that, irrespective of these considerations, the expansion rate of the universe does represent a separate parameter of the universe that requires precise fine tuning ("The Fine-Tuning of the Universe for Intelligent Life," 545).

18 Lewis and Barnes, *A Fortunate Universe*, 167.

19 For an explanation on how physicists calculate the lower bound of the fine tuning associated with the cosmological constant, see Chapter 8, n. c, at www.returnofthegod hypothesis.com/extendedresearchnotes.

20 For an extended discussion of why physicists now commonly agree that the degree of fine tuning for the cosmological constant is *no less than* 1 part in 10^{90}, see Chapter 8, n. d, at www.returnofthegodhypothesis.com/extendedresearchnotes.

21 Maria Temming, "How Many Stars Are There in the Universe?" *Sky & Telescope*, July 15, 2014, https://www.skyandtelescope.com/astronomy-resources/how-many-stars-are-there.

22 Lewis and Barnes, *A Fortunate Universe*, 50–51.
23 Lewis and Barnes, *A Fortunate Universe*, 79.
24 Lewis and Barnes, *A Fortunate Universe*, 177.
25 Carter, "Large Number Coincidences and the Anthropic Principle in Cosmology."
26 Brandon Carter defines two different versions of what is now commonly referred to as *the* weak anthropic principle, one of which he calls the "strong anthropic principle." His weak anthropic principle affirms that our local area in the cosmos (our planet, solar system, and galaxy) exhibits fine-tuning parameters that are necessarily consistent with our existence. His strong anthropic principle affirms that *the universe* exhibits fine-tuning parameters that are necessarily consistent with our existence. Since both of his anthropic principles cite necessary conditions of our existence rather than proposing a causal explanation for the fine tuning itself (either local or universal), both are subject to the same critique offered here. For simplicity's sake, I've combined Carter's two slightly different versions of the anthropic principle for the purpose of this critique. See also n. 28 below.
27 Leslie, "Anthropic Principle, World Ensemble, Design." See also Craig, "The Teleological Argument and the Anthropic Principle."
28 Barrow and Tipler, *The Anthropic Cosmological Principle*, 21. Brandon Carter similarly described the strong anthropic principle as the idea that "the Universe (and hence the fundamental parameters on which it depends) must be as to admit the creation of observers within it at some stage" ("Large Number Coincidences and the Anthropic Principle in Cosmology," 294). As Lewis and Barnes make clear, however, Carter did not propose this as a causal explanation of the fine tuning, as Barrow and Tipler described the strong anthropic principle in their 1988 book. As Lewis and Barnes explain, "Carter's SAP is easily misunderstood; the source of most confusion is the word *must*. The sense is not logical or metaphysical, that is, that a universe without observers is impossible. Neither is it causal, as if we made the Universe. Rather, this *must* is consequential, as in 'there is frost on the ground, so it must be cold outside.' *Given that we exist*, the Universe (and its laws) must allow observers" (*A Fortunate Universe*, 19).
29 Physicists define the "strong anthropic principle" differently. By the strong anthropic principle I am referring to the maximalist version of the principle as articulated by Barrow and Tipler in their classic 1988 work, *The Anthropic Cosmological Principle*. That version of the principle not only affirms that "the Universe must have those properties which allow life to develop within it at some stage in its history" and that "there exists one possible Universe 'designed' with the goal of generating and sustaining 'observers,'" but also that "observers are necessary to bring the Universe into being." This version of the principle (also called the participatory anthropic principle) affirms observers acting *after* the establishment of the fine-tuning parameters as the cause of the origin of the fine tuning.

Some physicists also use the term "strong anthropic principle" to designate more minimalist concepts (see notes 26 and 28 above), but those versions of the anthropic principle do not specify a cause for the origin of the fine tuning and thus do not present themselves as explanations for it; instead, they are simply facts about our universe. Thus, they do not warrant separate critique here except insofar as they are mistakenly interpreted as causal explanations of the fine tuning as, for example, the "weak anthropic principle" and Brandon Carter's version of the SAP are. Thus, definitional differences notwithstanding, I have attempted to critique all versions of the anthropic principle (weak or strong) that purport to offer causal explanations for the origin of the fine tuning. See Barrow, "Anthropic Definitions"; Barrow and Tipler, *The Anthropic Cosmological Principle*, 16–25.
30 Barrow and Tipler, *The Anthropic Cosmological Principle*, 16–25, esp. 21–22.
31 Gardner, "WAP, SAP, FAP & PAP."
32 Dembski, *The Design Inference*, 33–36. In my book, *Signature in the Cell*, I explained in a

more technical way why a "set of functional requirements" represents a kind of "independent pattern" and why Dembski's concept of specification thus subsumes both "independently recognized patterns" and "functional specifications." There I point out that systems that exemplify a set of functional requirements can be thought of as hitting a small independently definable target within a much larger combinatorial space of possibilities. See: *Signature in the Cell*, 360–363. See also Chapter 8, n. e., at: www.returnofthegodhypothesis.com/extendedresearchnotes.

33 As it happens the overwhelming majority of leading physicists accept that the universe does exhibit an extraordinary degree of fine tuning and that the fine tuning is real, not just apparent. In the recent book *A Fortunate Universe*, Lewis and Barnes give a partial list of such leading physicists that includes John Barrow, Bernard Carr, Brandon Carter, Paul Davies, Stephen Hawking, David Deutsch, George Ellis, Brian Greene, Alan Guth, Edward Harrison, Andrei Linde, Donald Page, Roger Penrose, John Polkinghorne, Martin Rees, Allan Sandage, Lee Smolin, Leonard Susskind, Max Tegmark, Frank Tipler, Alexander Vilenkin, Steven Weinberg, John Wheeler, and Frank Wilczek. As Barnes has explained, the scientists on this list "all agree that there is enough evidence for fine tuning that we should do something about it. The list is a roughly equal mix of theist, non-theist and unknown. The non-theists often reach for the multiverse. The theists are divided between those who think that the multiverse is a good scientific solution (especially Page) and those who think that God is required." In Chapters 13 and 16, I evaluate these competing interpretations. See Lewis and Barnes, *A Fortunate Universe*, 243; Luke Barnes, "Carroll's Five Replies to the Fine-Tuning Argument: Number 1," *Letters to Nature*, August 17, 2014, https://letterstonature.wordpress.com/2014/08/17/carrolls-five-replies-to-the-fine-tuning-argument-number-1.

34 Polkinghorne, "So Finely Tuned a Universe," 16.

Chapter 9: The Origin of Life and the DNA Enigma

1 Ayala, "Darwin's Greatest Discovery," 8567.

2 Dawkins, *The Blind Watchmaker*, 1, emphasis added.

3 Ayala, "Darwin's Greatest Discovery," 8567.

4 Crick, *What Mad Pursuit*, 138.

5 Kenyon and Steinman, *Biochemical Predestination*, 199–211.

6 "They [Thaxton, Bradley, and Olsen] believe, and I now concur, that there is a fundamental flaw in all current theories of the chemical origins of life" (Kenyon, Foreword to *The Mystery of Life's Origin*, vii).

7 Meyer, "Of Clues and Causes," 143–61.

8 Kamminga, "Studies in the History of Ideas on the Origin of Life," 222–45.

9 Shannon, "A Mathematical Theory of Communication."

10 Dretske, *Knowledge and the Flow of Information*, 6–10.

11 Moreover, information increases as improbabilities multiply. The probability of getting four heads in a row when flipping a fair coin is 1/2 × 1/2 × 1/2 × 1/2, or $(1/2)^4$. Thus the probability of attaining a specific sequence of heads and/or tails decreases exponentially as the number of trials increases. The quantity of information increases correspondingly. Even so, information theorists found it convenient to measure information additively rather than multiplicatively. Thus the common mathematical expression ($I = -\log_2 p$) for calculating information converts probability values into informational measures through a negative logarithmic function, where the negative sign expresses an inverse relationship between information and probability.

12 Dembski, *The Design Inference*, 1–35, 136–74.

13 Crick, "On Protein Synthesis," esp. 144, 153.

14 Dawkins, *River Out of Eden*, 17.
15 Gates, *The Road Ahead*, 188.
16 Hood and Galas, "The Digital Code of DNA."
17 Wald, "The Origin of Life," 44–53.
18 Lehninger, *Biochemistry*, 782.
19 Shapiro, *Origins*, 121; Kamminga, "Studies in the History of Ideas on the Origin of Life," 303–4.
20 Prigogine, Nicolis, and Babloyantz, "Thermodynamics of Evolution," 23.
21 De Duve, "The Constraints of Chance"; Crick, *Life Itself*, 89–93.
22 De Duve, "The Beginnings of Life on Earth," 437.
23 De Duve, "The Beginnings of Life on Earth," 437. Of course, examples of such reasoning abound in our ordinary experience. If, for instance, someone repeatedly rolls a pair of dice and turns up a sequence such as 9, 4, 11, 2, 6, 8, 5, 12, 9, 6, 8, and 4, no one would suspect anything but the interplay of random forces. Yet rolling ten (or, say, one hundred) consecutive sevens *in a game that rewards sevens* will justifiably arouse suspicion that something more than random forces are at work. Indeed, as we saw in the previous chapter, when a highly improbable event occurs that also conforms to a "functionally significant pattern," our uniform experience justifiably leads us to reject chance as the best explanation. Though most origin-of-life researchers have not been open to considering design as an option, they have rejected the chance hypothesis because they recognize that producing the genetic information necessary to synthesize proteins (and thus the first life) would require just such a conjunction of (a) an extremely improbable series of events with (b) a functionally significant outcome. Indeed, origin-of-life scientists recognize that the critical problem is not just generating an improbable series of molecular interactions that might result in, say, an improbable arrangement of bases in DNA. Instead, the problem is relying on a random shuffling of molecular building blocks to generate one of the very rare arrangements of bases in DNA (or amino acids in proteins) that also *performs a biological function*.
24 In 1977, the physicists Ilya Prigogine and Grégoire Nicolis proposed another theory of self-organization based on their observation that open systems driven far from equilibrium often display self-ordering tendencies (*Self-Organization in Nonequilibrium Systems*, 339–53, 429–47). For example, gravitational energy will produce highly ordered vortices in a draining bathtub, and thermal energy flowing through a liquid or viscous medium will generate distinctive convection currents, or "spiral wave activity." In his 1993 book *The Origins of Order*, Stuart Kauffman attempted to explain the origin of life based upon thermodynamic considerations as well (285–341; see also *At Home in the Universe*, 47–92). I critique these and other theories invoking *external* self-organizing forces (and nonequilibrium thermodynamics) in *Signature in the Cell* (253–70). In brief, I show that these theories do a good job of explaining symmetric or redundant order, but they do not explain the origin of the specified complexity or specified information that characterizes living systems. Physicist Brian Miller has also developed a powerful critique of the recent use of thermodynamic "fluctuation theorems" to explain—or at least render a bit less mysterious—the origin of life (see "Hot Wired: The Thermodynamics of Life," *Inference*, vol. 5, iss. 2).
25 For other arguments supporting this conclusion, see Chapter 9, n. a (as well as Chapter 14), at www.returnofthegodhypothesis.com/extendedresearchnotes.
26 Yockey, *Information Theory and Molecular Biology*, 274–81.
27 Dobzhansky, "Discussion of G. Schramm's Paper," 310.
28 De Duve, *Blueprint for a Cell*, 187.
29 Shapiro, "Prebiotic Cytosine Synthesis."
30 Wolf and Koonin, "On the Origin of the Translation System and the Genetic Code in the RNA World by Means of Natural Selection, Exaptation, and Subfunctionalization," 14.
31 Johnston et al. "RNA-Catalyzed RNA Polymerization."

32 De Duve, *Vital Dust*, 23.
33 Crick, *Life Itself*, 88.
34 Stein, Ben, *Expelled: No Intelligence Allowed* (documentary film). The Stein-Dawkins interview begins at time stamp 1:26:32.
35 Crick and Orgel, "Directed Panspermia."
36 Thaxton, Bradley, and Olson, *The Mystery of Life's Origin*, 211.
37 As Thaxton, Bradley, and Olson put it: "We have observational evidence in the present that intelligent investigators can (and do) build contrivances to channel energy down nonrandom chemical pathways to bring about some complex chemical synthesis, even gene building. May not the principle of uniformity then be used in a broader frame of consideration to suggest that DNA had an intelligent cause at the beginning?" (*The Mystery of Life's Origin*, 211).
38 Dean Kenyon, "Going Beyond a Naturalistic Approach to the Origin of Life," presentation at "Christianity Challenges the University: An International Conference of Theists and Atheists," Dallas, TX, February 9, 1985.
39 Peirce, "Deduction, Induction, and Hypothesis," 375.
40 Gould, "Evolution and the Triumph of Homology," 61.
41 Chamberlain, "The Method of Multiple Working Hypotheses," 754–59.
42 Lipton, *Inference to the Best Explanation*, 1.
43 Lyell, *Principles of Geology*, 75–91.
44 Kavalovski, "The Vera Causa Principle," 78–103.
45 Scriven, "Explanation and Prediction in Evolutionary Theory," 480.
46 Meyer, "Of Clues and Causes," 96–108.
47 Quastler, *The Emergence of Biological Organization*, 16.
48 Thaxton, Bradley, and Olson, *The Mystery of Life's Origin*, 42–172; Shapiro, *Origins*; Dose, "The Origin of Life"; Yockey, *Information Theory and Molecular Biology*, 259–93; Thaxton and Bradley, "Information and the Origin of Life"; Meyer, *Signature in the Cell*.
49 Of course, the phrase "large amounts of specified information" raises a quantitative question, namely, "How much specified information would a biomacromolecule (or a minimally complex cell) have to possess before that specified information implied intelligent design?" In *Signature in the Cell*, I give and justify a precise quantitative answer to this question. I show that the *presence* of roughly 500 or more bits of specified information reliably indicates intelligent design in a prebiotic context. For the basis of these calculations, see chaps. 8–10 of *Signature in the Cell* and esp. Chapter 9, n. b, at www.returnofthegodhypothesis.com/extendedresearchnotes. Suffice to say, for now, that many of the information-bearing biomacromolecules present in even the simplest one-celled organisms easily exceed this (specified) informational threshold.
50 Protein folds constitute the smallest unit of *structural* innovation in the history of life. See Chapter 9, n. c, at www.returnofthegodhypothesis.com/extendedresearchnotes; Meyer, *Darwin's Doubt*, 189–98, 219–27.
51 McDonough, *The Search for Extraterrestrial Intelligence*.
52 Dawkins, *River Out of Eden*, 133.

Chapter 10: The Cambrian and Other Information Explosions

1 Koonin, "The Biological Big Bang Model for the Major Transitions in Evolution."
2 Darwin, *On the Origin of Species* (1964), 129–30.
3 Darwin writes: "There is another and allied difficulty, which is much graver. I allude to the manner in which numbers of species of the same group, suddenly appear in the lowest known fossiliferous rocks. . . . To the question why we do not find records of these vast primordial periods, I can give no satisfactory answer." (*On the Origin of Species* (1964), 396–97).

4 For an extended discussion of, and relevant quotations from, paleontologists who have questioned the gradualistic Darwinian picture of the history of life, see Chapter 10, n. a, at www.returnofthegodhypothesis.com/extendedresearchnotes.
5 Bechly and Meyer, "The Fossil Record and Universal Common Ancestry."
6 Bechly and Meyer, "The Fossil Record and Universal Common Ancestry."
7 According to John Maynard Smith: "The fact of evolution was not generally accepted until a theory had been put forward to suggest how evolution had occurred, and in particular how organisms could become adapted to their environment; in the absence of such a theory, adaptation suggested design, and so implied a creator. It was this need which Darwin's theory of natural selection satisfied" (*The Theory of Evolution*, 42).
8 Huxley, "The Evolutionary Vision," 249, 253.
9 Eden, "Inadequacies of Neo-Darwinian Evolution as a Scientific Theory," 11.
10 For example, in 1980 the Harvard paleontologist and evolutionary biologist Stephen Jay Gould declared neo-Darwinism "effectively dead, despite its persistence as textbook orthodoxy" ("Is a New and General Theory of Evolution Emerging?" 120). See also Müller and Newman, "Origination of Organismal Form," esp. 7.
11 Müller, "The Extended Evolutionary Synthesis."
12 Müller and Newman, "Origination of Organismal Form," esp. 7.
13 Gilbert, Opitz, and Raff, "Resynthesizing Evolutionary and Developmental Biology." Andreas Wagner, *The Arrival of the Fittest* (New York: Penguin, 2014). The historical origins of this catchphrase are surprisingly complicated. Most who cite the phrase (e.g., evolutionary biologist Andreas Wagner) credit it to Hugo de Vries, but de Vries himself, in the last sentence of his 1904 monograph *Species and Varieties*, credits Arthur Harris: "Or, to put it in the terms chosen lately by Mr. Arthur Harris in a friendly criticism of my views: 'Natural selection may explain the survival of the fittest, but it cannot explain the arrival of the fittest'" (*Species and Varieties: Their Origin by Mutation*, 2nd ed., ed. Daniel Trembly MacDougal (Chicago: Open Court, 1906), http://www.gutenberg.org/files/7234/7234-h/7234-h.htm).
14 Peterson and Müller, "Phenotypic Novelty in EvoDevo," 328.
15 Denton, *Evolution: A Theory in Crisis*, 308–25.
16 Berlinski, *The Deniable Darwin*, 41–64.
17 Meyer, *Darwin's Doubt*, 169–84.
18 Axe determined the rarity of "function-ready" protein folds in a region of sequence space close to the wild-type beta-lactamase enzyme. His analysis showed that folds capable of performing beta-lactamase functions were extremely rare (i.e., 1 in 10^{77}) even in this specific region of amino acid sequence space. His result, therefore, implied an even greater rarity for functional folds in the vastly larger sequence space of possible amino acid combinations. This conclusion follows even taking into account the most optimistic estimates for the number of existing folds populating that space. Clearly, the probability of finding function-ready protein folds is higher close to known targets than elsewhere in sequence space. Axe, "Estimating the Prevalence of Protein Sequences Adopting Functional Enzyme Folds." For an earlier estimate also derived from mutagenesis experiments, see Reidhaar-Olson and Sauer, "Functionally Acceptable Solutions in Two Alpha-Helical Regions of Lambda Repressor." Weizmann Institute protein scientist Dan Tawfik has performed studies showing that as mutations accumulate, protein folds—first gradually and then increasingly quickly—lose their structural stability. For a discussion of how these and other recent results reinforce Axe's quantitative estimates of the rarity of protein folds, see the discussion in Chapter 15. See also Tokurik et al., "The Stability Effects of Protein Mutations Appear to Be Universally Distributed"; Tokuriki and Tawfik, "Stability Effects of Mutations and Protein Evolvability"; Bershtein et al., "Robustness–Epistasis Link Shapes the Fitness Landscape of a Randomly Drifting Protein"; Lundin et al., "Experimental Determination and Prediction of the Fitness Effects of Random Point Mutations in the Biosynthetic Enzyme HisA"; Bechly, Miller,

and Berlinski, "Right of Reply"; Miller, "A Dentist in the Sahara: Doug Axe on the Rarity of Proteins Is Decisively Confirmed."

19 Darwin, *The Life and Letters of Charles Darwin*, 278–79.

20 Mayr, Foreword, in Ruse, *Darwinism Defended*.

21 Meyer, *Darwin's Doubt*, 271–335. See also Meyer, Gauger, and Nelson, "Theistic Evolution and the Extended Evolutionary Synthesis." See also Chapter 15 of this book.

22 Quastler, *The Emergence of Biological Organization*, 16.

23 Again, the phrase "large amounts of specified information" elicits a quantitative question, namely, "How much specified information would a system have to have before it implied design?" As I explain in *Signature in the Cell* and *Darwin's Doubt*, the answer to that question depends upon the available probabilistic resources—the number of opportunities for solving a relevant search problem—in a given context. (See also Chapter 9, n. 50). In the context of biological evolution, the search for a novel protein fold defines the relevant search, and the duration of the evolutionary history of life on earth (roughly 3.85 billion years) and the number of organisms that have existed determines the maximum number of mutational trials that could have occurred—i.e., the available probabilistic resources.

Recall that a novel protein fold represents the smallest unit of innovation in the history of life. Since building fundamentally new forms of life requires structural innovation, mutations must generate new protein folds for natural selection to have an opportunity to preserve and accumulate structural or morphological innovations. Thus, the ability to produce new protein folds represents a *sine qua non* of macroevolutionary innovation.

Douglas Axe's discovery that protein folds are extremely rare in amino acid sequence space poses a formidable challenge to the creative power of the random mutation and natural selection mechanism. Though random mutations may produce slight changes in protein function within the structure of a common, preexisting fold, Axe's work showing the extreme rarity of "function-ready" folds (estimated at no better than 1 out of every 10^{77} amino acid sequences for a sequence of a relatively modest length) implies that generating new folds requires more information than could be reasonably expected to arise given the probabilistic resources available to earth's evolutionary history. Recall that there have been "only" 10^{40} organisms and replication events in the history of life on earth.

Since I also show that proposed alternative evolutionary mechanisms also fail to explain the origin of the amount of information necessary to generate proteins folds (*Darwin's Doubt*, 291–355), and that intelligent agents routinely solve informational search problems of much greater magnitudes (360–63), I argue that intelligent design provides the best explanation for the origin of the information necessary to account for fundamental innovation in the history of life.

For examples of failed attempts to demonstrate that mutation and natural selection can generate novel protein folds, see Berlinski and Hampton, "Hopeless Matzke "; Axe, "Answering Objections from Martin Poenie"; Axe, "More on Objections from Martin Poenie"; Gauger, "Protein Evolution"; Axe, "Show Me"; Meyer, *Darwin's Doubt*, 221–27. See also Miller, "A Dentist in the Sahara: Doug Axe on the Rarity of Proteins Is Decisively Confirmed," and Chapter 15 in this book.

24 Agassiz, "Evolution and the Permanence of Type," 444.

25 Dawkins, *The Blind Watchmaker*, 47–49; Küppers, "On the Prior Probability of the Existence of Life"; Schneider, "The Evolution of Biological Information"; Lenski et al., "The Evolutionary Origin of Complex Features." For a critique of these genetic algorithms and claims that they simulate the ability of random mutation and natural selection to generate new biological information apart from intelligent activity, see Meyer, *Signature in the Cell*, 281–95.

26 Rodin, Szathmáry, and Rodin, "On the Origin of the Genetic Code and tRNA Before Translation."

27 Denton, *Evolution: A Theory in Crisis*, 309–11.
28 Polanyi, "Life Transcending Physics and Chemistry"; "Life's Irreducible Structure."
29 Dawkins, *River Out of Eden*, 133.

Chapter 11: How to Assess a Metaphysical Hypothesis

1 The quote is also found in Sagan's book by the same title; see Sagan, *Cosmos*, 4.
2 Niiler, "Maybe You're Not an Atheist."
3 Carroll, "Turtles Much of the Way Down."
4 Carroll, *The Big Picture*, 11.
5 Dawkins, *River Out of Eden*, 133.
6 Peirce, "Deduction, Induction, and Hypothesis," 375.
7 In his essay "Deduction, Induction, and Hypothesis" Peirce outlined the differences between these three forms of inference. Deductive inferences apply a general rule to a particular case and yield logically necessary results. As he stated, for deductive inference, "the major premise lays down [the] rule, . . . the minor premise states a case under the rule, . . . [and] the conclusion applies the rule to the case and states the result." By contrast, Peirce defined induction as an inferential process in which rules are *generated* from knowledge of particular cases and results. As he stated, "Induction infers a rule." Peirce's third form of inference, which he called hypothesis or abduction, occurs when a particular case is postulated from knowledge of a rule and a fact or result. "Hypothesis," he stated, "infers from one set of facts of one kind to facts of another."
8 Meyer, "Of Clues and Causes," 25.
9 Gingerich, "The Galileo Affair"; see also *The Galileo Affair*, 110.
10 Peirce, "Deduction, Induction, and Hypothesis," 375.
11 Peirce, "Deduction, Induction, and Hypothesis," 375.
12 Work in the philosophy of science suggests that predictive success constitutes a special case of explanatory power in which a theory's ability to predict an event stands as evidence of its ability to explain it (Lipton, *Inference to the Best Explanation*). In addition, other work has shown that scientists can often explain events after the fact that they could not have predicted before the fact (Scriven, "Explanation and Prediction in Evolutionary Theory"). Still other work in the history of science has shown that the explanation of previously known facts often accounts more for the success of a theory than does a theory's ability to predict previously unknown events (Brush, "Prediction and Theory Evaluation"). All these results have suggested the primacy of explanation as an indicator of theory success. See also n. 21 below.
13 Chamberlain, "The Method of Multiple Working Hypotheses."
14 Meyer, "Of Clues and Causes," 90–97; Lipton, *Inference to the Best Explanation*, 1–5, 6–8, 56–74; Sober, *The Philosophy of Biology*, 27–46.
15 Cleland, "Historical Science, Experimental Science, and the Scientific Method"; "Methodological and Epistemic Differences Between Historical Science and Experimental Science."
16 Lipton, *Inference to the Best Explanation*; Meyer, "The Methodological Equivalence of Design and Descent," 67–112, 300–312, esp. 88–94.
17 For another homespun example of the way both explanatory power and considerations of simplicity contribute to the evaluation of competing possible explanations, see Chapter 11, n. a, at www.returnofthegodhypothesis.com/extendedresearchnotes.
18 In my books making the case for an intelligent design and in Chapters 9 and 10 of this book, I have shown how the case for intelligent design—which begins as an abductive inference—has been strengthened by just such a process of elimination, rendering the argument for intelligent design not just an abductive inference, but an abductive inference to the *best* explanation. See Meyer, *Darwin's Doubt; Signature in the Cell.*
19 Meyer, "Of Clues and Causes," 99–108, esp. 102.

20 Scriven, "Causes, Conditions and Connections in History," 249–50.

21 See Kline, "Theories, Facts, and Gods," 37–44. Kline argues that in cases where there is no known or observable cause of the effect or event in need of explanation, historical scientists may posit a novel causal theory by extrapolating from the powers of a cause known to be capable of producing a "relevantly similar" effect or event. Such extrapolation will generally need to be justified on some theoretical grounds. As Kavalovski has shown, Darwin used such a general strategy to establish the causal adequacy of natural selection. By drawing an analogy between artificial and natural selection, Darwin suggested that the latter could produce morphological change just as the former could. By invoking the theoretical consideration that natural selection would have more time in which to achieve its results, Darwin suggested that it was legitimate to expect (i.e., to extrapolate) that natural selection could produce more morphological change than artificial selection—enough to produce new species. Technically this method of reasoning did not meet the strict requirements of *vera causa*, because historical scientists cannot observe natural selection producing the amount of morphological change required by the fossil record and the extant diversity of life. Nevertheless, as Kavalovski notes, the use of analogy and extrapolation (justified theoretically) was widely accepted by influential philosophers even before Darwin as a valid strategy for establishing causal adequacy ("The Vera Causa Principle," 104–29).

22 For a more extensive primer on Bayesian probability calculus, see Chapter 11, n. b, at www.returnofthegodhypothesis.com/extendedresearchnotes.

23 For a discussion of an objection known as the "problem of old evidence" to the use of the Bayesian formalism to evaluate hypotheses, see Chapter 11, n. c, at www.returnofthegodhypothesis.com/extendedresearchnotes.

24 There is a common objection to the use of both inference to the best explanation and Bayesian analysis to test hypotheses. Specifically, philosophers of science worry that inference to the best explanation as a method and the Bayesian formalism used in support of it treat already known evidence and new evidence equally when assessing the effect of evidence on the strength of a hypothesis. (This objection is also related to the problem of "old evidence"; see n. 23 above.) In other words, in inference to the best explanation and the Bayesian formalism, the ability to explain already known evidence counts just as much in support of a hypothesis as predicting a previously unknown event, phenomenon, or piece of evidence (see Talbott, "Bayesian Epistemology").

Indeed, in these methods of hypothesis testing, the relationship between hypothesis and evidence is unaffected by the way it comes to an observer in time. Some philosophers of science worry, therefore, that when evidence presents itself before scientists predict it, scientists can "accommodate" or gerrymander the features of their proposed explanations to match the evidence in question. Such explanations, so goes the worry, will not explain anything other than the evidence at hand and will fail to bring deeper understanding about the world—that is, understanding not provided already by the data themselves. In other words, such explanations will lack broader explanatory power or depth. Historians and philosophers of science characterize such explanations as ad hoc. They also note such explanations can become extremely convoluted in order to match the data at hand as, for example, those of Ptolemaic astronomy did with their use of epicycles to describe planetary motions. When hypotheses require complex interactions between multiple theoretical entities to explain the evidence, historians and philosophers of science think that reliance on these explanations may obscure deeper regularities or patterns of cause and effect at work in nature. In short, what gerrymandered explanations after the fact may gain in empirical adequacy, they may lose in parsimony, explanatory depth, and prior plausibility.

Most historians and philosophers of science acknowledge that explaining events after the fact does create more of an opportunity for scientists to contrive explanations in ways that can diminish parsimony, explanatory depth, and coherence. Nevertheless, *post* *hoc* hypotheses with explanatory power need not lack these and other explanatory virtues. Indeed, the recognition of the presence or absence of other explanatory virtues often tacitly complements assessments of causal adequacy and explanatory power and figures into determinations about which among a competing set of explanations qualifies as best. Thus, there is no reason to reject explanations of already known facts simply because they may not also make predictions, unless such explanations also lack coherence or parsimony, for example. Instead, there may be good reasons to accept such explanations, especially if in addition to explanatory power and causal adequacy they exhibit other explanatory virtues such as coherence, parsimony, explanatory depth, and breadth.

As the University of Maryland historian of science Stephen Brush has shown, many theories in physics were initially accepted because of their ability to explain already known facts and anomalies better than previously dominant theories. Brush shows, in particular, that physicists accepted Einstein's theory of general relativity more because of its immediate ability to explain known facts than because of its later successful predictions. (See Brush, "Prediction and Theory Evaluation." For specifically Bayesian responses to this problem, see Horwich, *Probability and Evidence*; Maher, "Prediction, Accommodation, and the Logic of Discovery.") In any case, I will show in later chapters that the God hypothesis not only exhibits greater causal adequacy than competing metaphysical hypotheses, but that it also exhibits other explanatory virtues such as simplicity/parsimony, explanatory breadth and depth, internal consistency and coherence, and fruitfulness. (See Keas, "Systematizing the Theoretical Virtues.")

25 I'm indebted to philosopher of science Tim McGrew for this excellent illustration.

26 Meyer, "The Return of the God Hypothesis."

27 Richard Dawkins, "Why There Almost Certainly Is No God," *Edge*, October 25, 2006, https://edge.org/conversation/richard_dawkins-why-there-almost-certainly-is-no-god.

Chapter 12: The God Hypothesis and the Beginning of the Universe

1 For a more complete explication of the logical structure of the Kalām cosmological argument for God's existence, see Chapter 12, n. a, at www.returnofthegodhypothesis.com/extendedresearchnotes.

2 This argument was known as the trademark argument. Some philosophers questioned its first premise, that finite human beings have a clear and distinct idea of a perfect, infinitely powerful or infinitely wise God. Others questioned the second premise, the idea that only God could cause the idea of a perfect being in our minds.

3 Dembski and Meyer, "Fruitful Interchange or Polite Chitchat?," 418–22.

4 See Moser, *The Elusive God*, 243–45.

5 McMullin, "How Should Cosmology Relate to Theology?," 39.

6 McMullin, "How Should Cosmology Relate to Theology?," 39.

7 Quoted in Browne, "Clues to Universe Origin Expected."

8 Gen. 1:1.

9 Isa. 51:16; Isa. 45:12; Ps. 104:2; Jer. 12:10; Zech. 12:1; 2 Tim. 1:9; Titus 1:2.

10 As quoted in Sutton, "Review of *Einstein's Universe*."

11 Of course, in addition to this primary sense of "bringing into being that which did not previously exist," many versions of theism also affirm that God sustains the universe in existence moment by moment. Some theists think of this sustaining power as part of God's role as the creator; others think of it as a separate power. Even those who think of it as part of the way God functions as creator also typically think of God's sustaining the universe as a secondary sense of creating, the need for which follows from the primary act of God's having brought the universe into existence in the first place.

Some theists, typically analytical philosophers, do deny that God *necessarily* acted to create the universe at a point in time in the finite past. For example, a famous argument for God's existence, the "argument from contingency," offers God as the sufficient reason and best explanation for the existence of the universe and its contingent features whether the universe had a beginning or not. Philosophers who offer such proofs often conceive of God, at least for the sake of argument, as continually creating and sustaining the universe on a moment-by-moment basis rather than having created it at a specific time in the finite past. They think of God as "the ground of all being," who continuously sustains the universe in existence, and they suggest that God has possibly done so for an infinitely long time.

Even so, there are reasons for theists to prefer the idea that God both creates and sustains the universe over the view that God only sustains it. First, creation without a beginning has no precedent in our experience. Instead, in our experience, creators with powers of deliberation will bring various "creations" (bridges, paintings, cars, cell phones, etc.) into existence that did not exist before. Indeed, creation implies a new entity coming into being and thus temporal sequence and beginning.

In addition, as many theistic philosophers from the Middle Ages to the present have argued, the idea that God continually creates time as well as space, matter, and energy but has been doing so for an infinitely long time generates various absurdities.

Similarly, St. Bonaventure, for one, argued that the universe could no more have had an infinite past than a man could have climbed out of a hole infinitely deep (Moreland, *Scaling the Secular City*, 31). Just as a man, climbing up from an infinitely deep hole one step at a time, would never reach the top because he would have an infinite distance to traverse, a universe that began an infinitely long time ago would never reach the present through a series of temporal events, because an infinitely long time would have had to have transpired before that series of events could reach the present moment.

As William Lane Craig has argued, potential infinities (or the idea of approaching infinity as a mathematical limit) make sense, but "a collection of things" or events "formed by adding one member after another can't be actually infinite" in reality. Craig explains why. A collection formed by adding one member to another can never actually be infinite because no matter how many members might exist in the collection, they could be numbered *and* one more could always be added before reaching an infinite number. And since a series of events in time is a "collection formed by adding one member to another," it follows that a series of events in time cannot form an actual infinite either. That means that the universe could not have begun an infinitely long time ago even if God existed to create it "then" (Craig, *Reasonable Faith*, 98–99).

12 See n. 11 above for a discussion of the implausibility of positing an actual infinite, including an actual temporally infinite universe, and thus the implausibility of positing that God created such a temporally infinite universe.

13 Indeed, though some versions of theism expect a temporally finite universe and other versions might not expect or at least require it, naturalism (at least, *basic* naturalism) would not expect the physical universe to have a beginning at all. Thus, the evidence that we actually have of a temporally finite universe is better explained by theism than by basic naturalism.

14 Dicke et al., "Cosmic Black-Body Radiation," 415.

15 Eddington, "The End of the World," 450. Eddington was raised a Quaker and may have retained some religious sensibilities or even theistic belief into his adult life. Nevertheless, in his work as an astronomer he was a functional materialist, accepting methodological materialism as a normative canon of method. Thus, he would have found a picture of the universe that was effectively impossible to explain materialistically "repugnant."

16 There may now be reasons to think the singularity theorems are more well-grounded than current opinion in physics suggests, since, as I show in Chapter 16 (pp. 341–42), the inflationary models that justify doubting the applicability of the singularity theorems have encountered significant explanatory difficulties.

17 Recall that a prior probability in Bayesian analysis is the probability of some hypothesis,

P(H), before some body of new or relevant evidence is taken into account. Usually that means that estimates of prior probabilities are based upon the background knowledge that we have before we begin to assess a hypothesis with respect to such new evidence. Nevertheless, when assessing competing worldviews or metaphysical hypotheses, some philosophers think it entirely legitimate to assume that no worldview should be considered any more intrinsically or inherently probable than another. In the case of theism, the situation is complicated; some philosophers argue that considerations of symmetry dictate equal priors for theism and atheism, while others appeal to simplicity considerations or entailments to argue that one of these views should be given at least a modest preference over the other.

These issues are subtle and complex, but for the purposes of our argument we need not resolve them. Virtually no one argues that the ratio of the prior probabilities for theism and atheism, $P(T) \mid P(\sim T)$, is very far from 1. But if the argument of this book is correct, the ratio of the cumulative likelihoods, $P(E_1 \,\&\, \ldots \,\&\, E_n \mid T) \mid P(E_1 \,\&\, \ldots \,\&\, E_n \mid \sim T)$, is very large indeed, large enough to swamp even a hefty skeptical ratio of the priors. In the absence of a compelling reason to think that the prior probabilities are wildly skewed against theism, the empirical evidence that we marshal *a posteriori* will and should predominate in assessment of the plausibility of competing hypotheses. Insofar as the evidence considered in Chapters 4–6 is much more strongly expected given theism than materialism or naturalism, that evidence not only confers greater epistemic support on theism than materialism, but, as I show in subsequent chapters, the whole ensemble of evidence under consideration (in Chapters 4–10) also makes theism the most reasonable thing to believe, all things considered.

18 Personal interview with William Lane Craig, July 1994, Cambridge, England.

19 Hawking and Penrose, "The Singularities of Gravitational Collapse and Cosmology."

20 Moreland, *Scaling the Secular City*, 42.

21 As Moreland notes: "Naturalists like John Searle, John Bishop, and Thomas Nagel all admit that our basic concept of action [i.e., human choice or decision] is itself a libertarian one. Searle goes so far as to say that our understanding of [physical or material] event causality is conceptually derived from our first-person experience of our own causation. There is a major tradition in philosophy that agent causation is clearer and more basic than event [i.e., physical or material] causation, and it may actually be that if any sort of causation is inscrutable, it is [such] event causation" (Moreland, "The Explanatory Relevance of Libertarian Agency as a Model of Theistic Design," 273–74).

22 Moreover, considerable neurophysiological evidence now supports the reality of human libertarian agency or some form of mind-body dualism. See, for example, Custace, *The Mysterious Matter of Mind*; Beauregard and O'Leary, *The Spiritual Brain: A Neuroscientist's Case for the Existence of the Soul*. Nevertheless, whatever one thinks about the debate between mind-body dualists and physicalists, it remains the case that simply positing libertarian free agency to explain the beginning of the universe does circumvent the explanatory conundrum confronting naturalists or materialists. As J. P. Moreland explains, "The only way for the first event to arise spontaneously from a timeless, changeless, space-less state of affairs, and at the same time be caused, is this—the event resulted from the free act of a person or agent. In the world, persons or agents spontaneously act to bring about events. I myself raise my arm when it is done deliberately. There may be necessary conditions for me to do this (e.g., I have a normal arm, I am not tied down), but these are not sufficient. The event is realized only when I freely act. Similarly, the first event [i.e., the beginning of the universe] came about when an agent freely chose to bring it about, and this choice was not the result of other conditions which were sufficient for that event to come about" (Moreland, *Scaling the Secular City*, 42).

23 Haldane, *Possible Worlds and Other Essays*, 209.

24 As J. P. Moreland has explained in response to materialists who deny the intelligibility of a

personal agent cause as the best explanation for the beginning of the universe: "The Divine creation of the initial singularity is precisely analogous to human libertarian acts; for example, both involve first movers who initiate change. There is nothing particularly mysterious or inscrutable about the latter, so in the absence of some good reason to think that there is some specific problem with the initial Divine creation, the charge of inscrutability is question begging. Moreover, we understand exercises of [will] power primarily from introspective awareness of our own libertarian acts, and we use the concept of action so derived to offer third-person explanations of the behavior of other human persons. There is nothing obscure about such explanations for the effects produced by other finite persons, and I see no reason to think that this approach is illicit in the case of Divine initial creation" (Moreland, "The Explanatory Relevance of Libertarian Agency as a Model of Theistic Design," 273–74). See also: Moreland, J.P. "Agent Causation and the Craig/Grünbaum Debate about Theistic Explanation of the Initial Singularity," 539–54.

25 Anthony Aguirre and John Kehayias, "Quantum Instability of the Emergent Universe."

26 Spinoza, like many Eastern philosophers, equates God and nature, but, unlike many Eastern pantheistic philosophers, does regard God as possessing rationality as opposed to simply constituting the impersonal unity or oneness of all reality. See Kaufmann and Baird, *Philosophical Classics*, 478, 479–86.

27 Ferm, *An Encyclopedia of Religion*, 557–58.

28 See Sire, *The Universe Next Door*, 118–35.

Chapter 13: The God Hypothesis and the Design of the Universe

1 "*The Abrams Report* for September 29, 2005."

2 Dawkins, *River Out of Eden*, 133.

3 Carroll, "Turtles Much of the Way Down."

4 Some object to the fine-tuning argument by asking why God would need to fine-tune a universe at all. "Surely," they ask, "if God wanted a life-permitting universe, God wouldn't perch it on a razor's edge." The argument presented here circumvents this objection by showing that the inference to a transcendent designer better explains the evidence we have (based upon what we know about the features that designed systems typically exhibit) without speculating about why a designing intelligence would have chosen to fine-tune the universe the way it did.

5 Physicist Luke Barnes formulates the argument slightly differently. Rather than focusing on the probability of the fine tuning per se given either theism or naturalism, he focuses on the probability of a *life-permitting universe* given either theism or naturalism (given what we know about the fine tuning). He articulates the argument as follows:

Premise One: For two theories T_1 and T_2, in the context of background information B, if it is true of evidence E that $P(E \mid T_1 B) \gg P(E \mid T_2 B)$, then E strongly favors T_1 over T_2.

Premise Two: The likelihood that a life-permitting universe exists on [given] naturalism is vanishingly small.

Premise Three: The likelihood that a life-permitting universe exists on [given] theism is not vanishingly small.

Conclusion: Thus, the existence of a life-permitting universe strongly favors theism over naturalism.

Barnes has written an excellent article titled "A Reasonable Little Question: A Formulation of the Fine-Tuning Argument" in which he develops this argument by defending each of the above premises. He especially focuses on using what physicists know about the quantitative precision of the physical constants to support Premise 2 above. I draw on his work to support a slightly modified version of that premise (in my version of the fine-tuning argument) in this chapter. Barnes then uses his formulation of the argument to respond to many common objections to the fine-tuning argument for the existence of God. Among others, he addresses such objections as: (a) deeper physical laws explain the fine tuning; (b) the multiverse explains the fine tuning; and (c) we can't know whether God would be inclined to create a finely tuned or a life-permitting universe since what God would do is inscrutable.

I find both Barnes's argument as he formulates it and his responses to these objections persuasive and compelling. Nevertheless, I have chosen to formulate the argument from fine tuning slightly differently in this chapter. I have emphasized what we know from our uniform and repeated experience about characteristic features of designed objects to suggest that we do have a strong empirically based reason to expect that a designing mind would fine-tune the parameters necessary for life. Recall that fine tuning represents (a) a highly improbable set of conditions or values that (b) exemplify a set of functional requirements, making possible a functional or significant outcome. Recall also that intelligently designed objects and systems often exemplify precisely these features in combination. Indeed, producing finely tuned systems is one of the things that intelligent agents frequently and uniquely do. I argue further that, since fine tuning has been present from the beginning of the universe, the evidence of fine tuning points to a *transcendent* intelligence rather than an immanent one.

By arguing this way, I do not need to justify the idea that we have reason to expect God would have produced a *life-permitting* universe. Instead, I only need to justify the idea that we have reason to expect that an intelligent agent would produce *a finely tuned system*, since, again, we have ample evidence of agents doing just that. I prefer this way of making the argument, because Bayesian likelihoods (i.e., assessments of the probability of the evidence E given the hypothesis H) are determined largely by considerations of causal adequacy—that is, by reference to our knowledge of cause and effect. Making the argument this way allows us to employ our empirically based knowledge of cause and effect to suggest that the probability/expectation of the fine-tuning evidence given a design hypothesis is high, and certainly higher than the probability of that evidence given naturalism. In other words, the fine tuning *would be expected* given the activity of a preexisting designing intelligence—one that I argue on other grounds must possess the attribute of transcendence.

By contrast, Barnes must defend the proposition that a *life-permitting* universe (rather than the fine tuning necessary to produce it) would be expected given theism—or, as he puts it, "the probability that a life-permitting universe exists on theism is not vanishingly small." He gives a perfectly good justification for that proposition that turns, first, on the attributes associated with the concept of God. Thus, he also rejects the idea that the intentions of God (so conceived) would be utterly inscrutable. In any case, he shows that however much we might be uncertain about whether God would be inclined to create a life-permitting universe, we certainly have greater reason to expect such a universe given theism than naturalism.

Barnes's defense of his third premise, and his argument as a whole, is compelling. Nevertheless, I prefer to make the argument by focusing on the probability of the *fine tuning itself*, rather than the probability of a *life-permitting* universe, given theism or naturalism. I do so, because this way of making the argument appeals directly to our uniform and repeated experience, rather than just to our concept of God, to generate the Bayesian likelihoods. Indeed, whereas we have observed intelligent agents generating finely tuned systems (highly improbable arrangements of parts or conditions that exemplify a functional specification), we do not have a similar direct observation of God producing life.

Even so, I don't deny the force of Barnes's argument since, as I explained in Chapter 11, theoretical considerations can justify claims of causal adequacy in other ways. Indeed, I think he answers the "God's intentions are inscrutable" objection persuasively. Thus, I regard his argument and the one presented in this chapter as complementary ways of reaching the same conclusion.

Several other ways of making the fine-tuning argument also have formidable force. See, e.g., Swinburne, *The Existence of God*; Leslie, *Universes*; Craig, "Design and the Anthropic Fine-Tuning of the Universe"; Collins, "The Teleological Argument." For a philosopher of science who makes the argument by assessing the probability of the fine tuning given theism as opposed to naturalism (as do I), see Roberts, "Fine-Tuning and the Infrared Bull's-Eye."

6 Crick, *Life Itself*, 88, 95–166. See also Crick and Orgel, "Directed Panspermia."

7 Hoyle and Wickramasinghe, *Evolution from Space*, 35–50.

8 Stein, *Expelled*.

9 Crick, *Life Itself*, 88.

10 Dawkins, "Ben Stein vs. Richard Dawkins Interview."

11 See also Sober, "Intelligent Design Theory and the Supernatural —The 'God or Extraterrestrial' Reply," 1–12. Sober, a philosophical naturalist who rejects the case for intelligent design, argues that *if* one does accept the argument for intelligent design in biology (from irreducible complexity), it makes more sense to affirm a supernatural designer than an extra-terrestrial one. He argues that the "minimalist case" for intelligent design when supplemented with a few additional and plausible premises (such as, for example, "the universe is finite") leads logically to the conclusion that a transcendent intelligent designer must exist.

12 Another metaphysical hypothesis that posits an immanent form of intelligence as the prime or ultimate reality is known as panpsychism. Panpsychism holds that a universal mind or ubiquitous consciousness present in the universe, and partially present in each part of the material universe, underlies all of reality (Goff, Seager, and Allen-Hermanson, "Panpsychism"). Critics of panpsychism worry that it fails to give an account of how one conscious mind—for example, my mind—differs from another, say, yours. They ask: if all matter is part of the same universal consciousness, what makes one mind different than another? On what basis can our ordinary experience of having individual minds separate from each other be affirmed if all that ultimately exists is a single universal mind? A popular form of panpsychism among some analytical philosophers known as emergent panpsychism addresses this dilemma by arguing that the smallest constitutive parts of the material universe have little "droplets" of proto-consciousness, but as more complex material arrangements emerge more developed forms of consciousness arise. This makes it possible to affirm a universe in which many minds evolve within one emerging universal mind. Whatever advantages panpsychism may offer over materialism as a philosophical concept, both versions of it—i.e. straight panpsychism and emergent panpsychism—lack promise as explanations for the *origin of the material* universe and the origin of its fine tuning. Indeed, all forms of panpsychism, and especially popular emergent panpsychism, deny the existence of any transcendent conscious agent existing outside of, or prior to, matter coming into being. Instead, since consciousness and matter (or mass-energy) are co-extensive, panpsychism necessarily must affirm that mind and matter would have begun coterminously with the beginning of the universe—if, indeed, the universe had a beginning as the evidence suggests that it did. Thus, panpsychism necessarily denies any entity separate from the universe that could explain its origin or fine tuning, two of the three classes of evidence about cosmological and biological origins under examination here. And yet, as I have argued, adequately explaining the origin of the material universe and its fine tuning require positing just such a transcendent and intelligent entity.

13 Carroll, "Turtles Much of the Way Down."

14 Ugural and Fenster, "Hooke's Law and Poisson's Ratio."

15 Polanyi, "Life Transcending Physics and Chemistry," 61.

16 Polanyi, "Life's Irreducible Structure," esp. 1309.

17 Barnes, "The Fine-Tuning of the Universe for Intelligent Life," 530; Halliday and Resnick, *Physics: Part Two*, appendix B, A23.

18 Susskind, *The Cosmic Landscape*.
19 Dawkins, *River Out of Eden*, 133.
20 Recall from Chapter 8, n. 11, that the entropy required for life in a stable galaxy is not as extreme as the initial entropy required to produce the low-entropy universe that we actually have. Whereas Roger Penrose has calculated the entropy fine tuning necessary to generate our low-entropy universe as $10^{10^{123}}$ my colleague Brian Miller calculates the initial entropy to produce a life-permitting galaxy at "just" $10^{10^{98}}$. For the basis of Miller's calculations see, again, Chapter 8, n. a, at www.returnofthegodhypothesis.com /extendedresearchnotes.
21 Recall from n. 5 above that Barnes takes a slightly different tact than I do in *what* he calculates and in how he makes use of his calculation in his version of the fine-tuning argument. He calculates the probability of a *life-permitting universe* given naturalism, whereas I calculate the probability of the fine tuning given naturalism. But since a life-permitting universe also depends precisely and directly upon the fine tuning of the constants of physics and the initial conditions of the universe, the precise quantitative degree of the fine tuning also allows me to calculate the probability of observing *the fine tuning itself* given naturalism. And, of course, the two probabilities are the same. In addition, rather than arguing, as I do, that the observation of the exquisite fine tuning of the universe for life "confirms precisely what we might well expect if a purposive intelligence . . . had acted to design the universe and life," he argues that "the likelihood that a *life-permitting* universe exists on theism is *not* vanishingly small." He focuses on the probability given theism of a life-permitting universe as opposed to the fine tuning that makes a life-permitting universe possible. He also makes a more modest claim about what we have reason to expect based upon theism than I do, in part because he bases his argument on the properties associated with God, whereas I base my assessment of likelihoods on our repeated experience of the attributes (small probability specifications) of designed objects and systems that relevantly similar intelligent agents are known to produce. Using Bayesian analysis we both come to similar conclusions. He argues that the probability of a *life-permitting universe* (given the high degree of fine tuning we observe) is much less expected (and less probable) given naturalism than theism. I argue that the probability of observing the *extreme degree of fine tuning* that we do in the universe is much less expected (and less probable) given naturalism than theism. Consequently, we both agree the fine tuning provides greater evidential support for theism than naturalism.
22 See n. 5.
23 See Sire, *The Universe Next Door*, 119–35.
24 Indeed, according to some forms of Eastern pantheism (for example, the Sankara school of Vedanta Hinduism), even our own awareness of ourselves as conscious minds separate from the oneness of nature (*brahman*) represents an illusion or false consciousness. For an amplifying discussion of this point, see Chapter 13, n. a, at www .returnofthegodhypothesis/extendedresearchnotes; and Kohler, *Asian Philosophies*, 81.
25 Sean Carroll and others object to this by arguing that there is no reason for the concept of a cause to be extended beyond the physical universe. Yet holding that position denies the principle of sufficient reason.

Chapter 14: The God Hypothesis and the Design of Life

1 See Lamoureux, "Evolutionary Creation." In the following notes, I will refer to this online essay. See also his recent book-length treatment, *Evolutionary Creation: A Christian Approach to Creation*.
2 Lamoureux, "Evolutionary Creation," 2.
3 Quoted in Woodward, "The End of Evolution," 33.
4 Lamoureux, "Evolutionary Creation," 2.

5 Lamoureux, "Evolutionary Creation," 3.
6 Lamoureux, "Evolutionary Creation," 2.
7 Lamoureux, "Evolutionary Creation," 1n1.
8 The information in other stretches of DNA—specifically, that in the nonprotein-coding regions—helps to regulate the timing of expression of the information contained in the coding regions. In addition, higher levels of "ontogenetic" (beyond the genes) information are also stored in cytoskeletal arrays, the distribution of membrane targets, and supracellular structures, tissues, and organs. These more structural forms of information also play crucial roles in the regulation and expression of specifically genetic information. Ontogenetic information necessary for animal development is also transmitted between cells by sugar-signaling molecules via the "sugar code." See Wells, "Membrane Patterns Carry Ontogenetic Information That Is Specified Independently of DNA"; Meyer, *Darwin's Doubt*, 271–87.
9 Dawkins, *River Out of Eden*, 17; Gates, *The Road Ahead*, 228; Hood and Galas, "The Digital Code of DNA."
10 Clearly, these two possibilities are contradictory. If *all* the information necessary to produce either the first life or new forms of life was present at the start of the universe, then the evolutionary process would not need to generate any new genetic information or novelty. Instead, it would just be unfolding what was already "in" the initial conditions of the universe. But if *new* information was generated, then clearly the initial and boundary conditions must have lacked at least some of the information needed to generate life or build new forms of life.
11 Lamoureux, "Evolutionary Creation," 1.
12 For a definition of specification, see Dembski, *The Design Inference*, 1–66, 136–74.
13 Eigen, *Steps Towards Life*, 12. Eigen's statement also contradicts what is known as algorithmic information theory. Algorithmic information theory states that the amount of information or data that a system outputs *cannot* exceed the amount input into the system or the amount in the algorithm that operates upon the system (Chaitin, *Algorithmic Information Theory*).
14 Dretske, *Knowledge and the Flow of Information*, 12.
15 Alberts et al., *Molecular Biology of the Cell*, 105.
16 Polanyi, "Life Transcending Physics and Chemistry"; see also "Life's Irreducible Structure," esp. 1309.
17 Küppers, *Information and the Origin of Life*, 170–72; also Thaxton and Bradley, "Information and the Origin of Life"; also Thaxton, Bradley, and Olson, *The Mystery of Life's Origin*, 24–38.
18 Kok, Taylor, and Bradley, "A Statistical Examination of Self-Ordering Amino Acids in Proteins."
19 Lamoureux, "Evolutionary Creation," 3.
20 Tompa and Rose, "The Levinthal Paradox of the Interactome," 2074.
21 Tompa and Rose themselves think that the cell must have emerged as the result of some "preferred pathways" or by an "iterative hierarchic assembly of its component sub-assemblies" as opposed to either a straightforward deterministic (or self-organizational) process or a random process. Nevertheless, they posit no specific process that could overcome the combinatorial complexity that they describe. Instead they state: "The central biological question of the twenty-first century is: how does a viable cell emerge from the bewildering combinatorial complexity of its molecular components? Here, we estimate the combinatorics of self-assembling the protein constituents of a yeast cell, a number so vast that the functional interactome could only have emerged by iterative hierarchic assembly of its component sub-assemblies. *We surmise that this non-deterministic temporal continuum could not be reconstructed de novo under present conditions*" ("The Levinthal Paradox of the Interactome," 2074, emphasis added).

22 Recall that I also showed in Chapter 10, and in *Darwin's Doubt* (chaps. 8–16), that all currently proposed evolutionary processes fail to account for the large increases in genetic and epigenetic forms of information necessary to build new forms of life after the beginning of the universe.

23 Shannon describes this process of error correction using a correction channel as follows: "We consider a communication system and an observer (or auxiliary device) who can see both what is sent and what is recovered (with errors due to noise). This observer notes the errors in the recovered message and transmits data to the receiving point over a 'correction channel' to enable the receiver to correct the errors." He then proposes his tenth theorem: "*Theorem 10:* If the correction channel has a capacity equal to $H_y(x)$ it is possible to so encode the correction data as to send it over this channel and correct all but an arbitrarily small fraction ε of the errors. This is not possible if the channel capacity is less than $H_y(x)$." His accompanying diagram, Figure 8, makes clear that the correction channel supervenes over the transmission channel and often depends upon an observer to detect deviations from the original transmission of information ("A Mathematical Theory of Communication").

24 W. Ross Ashby's "law of requisite variety" advanced a similar (indeed, mathematically "isomorphic") principle that he discovered in the context of "self-organization" theory. Ashby's principle states that the control or design of an informational process depends on a correction channel that has a capacity *equal to or greater than* all the possible states that a system can adopt. For even small physical systems the number of possible states can be hyperastronomical (a problem known in control theory as the "curse of dimensionality"; "Requisite Variety and Its Implications for the Control of Complex Systems").

25 Some physicists have argued against an indeterministic and probabilistic interpretation of quantum mechanics. Consequently, they regard quantum indeterminacy as only apparent and not real. The small minority of physicists who hold to the Bohmian interpretation of quantum mechanics, for example, argue that "hidden variables" follow deterministic laws that drive the evolution of quantum states (Vaidman, "Quantum Theory and Determinism"). Therefore, on this view, measurements that appear to result from random events actually stem from the hidden variables changing with time according to some law or algorithm. This view, if true, could be used to challenge the argument presented against front-loaded design in this chapter. Some might suggest, for example, that an omniscient God could have set all of the hidden variables in some region of space at the start of the universe to the specific values needed to ensure that natural processes would generate a cell billions of years in the future. Therefore, the information required to build the first cell would not need to enter the biosphere as the result of a later direct action or "intervention" of an intelligent agent. This way of formulating the front-loaded design idea might seem reasonable at first, but it is implausible due to the chaotic dynamics that govern the interactions of large systems of particles. For a more complete explanation as to why, see Chapter 14, n. a, at www.returnofthegodhypothesis/extendedresearchnotes. See also Dellago and Posch, "Kolmogorov-Sinai Entropy and Lyapunov Spectra of a Hard-Sphere Gas").

26 In classical theism, the omniscience and omnipotence of God are closely related doctrines. God is omniscient in part because God is omnipotent. Consequently, some theists have argued that God might be causing the collapse of the wave function as a way of understanding both God's omniscience and the basis of the regularity of natural law despite the underlying stochastic nature of quantum processes. By contrast, a deistic God who does not exercise omnipotence over nature after the beginning would seem to lack the attributes (immanence and omnipotence) necessary to omniscience, at least, in a world of quantum fluctuations and indeterminacy such as ours.

27 There may be an even deeper problem with this whole line of thinking. The front-loaded design hypothesis of Denis Lamoureux and others seems to assume that life could be

generated from an essentially computational process. In short, it seems to assume the validity of what is known as the "Church-Turing conjecture" in computer science, which asserts that natural laws and processes can be represented as a computational process. For a discussion of why this tacit assumption of front-loaded design models fails, see Chapter 14, n. b, at www.returnofthegodhypothesis/extendedresearchnotes.

28 According to modern quantum theory, the interactions and evolution of subatomic particles and energy in the universe do not operate like large-scale objects such as billiard balls, which follow clear trajectories and interact predictably according to deterministic laws. At microscopic levels, a physical system must be described quantum mechanically using probability distributions describing the probability of a given state of affairs arising from some prior state or condition. For example, unlike billiard balls interacting deterministically in accord with the law of conservation of momentum, the angle at which a subatomic particle deflects off of another much larger particle cannot be exactly known beforehand. Instead, physicists can only calculate the probability of that particle adopting a particular angle of refraction. Likewise, an atom in an excited energy state will eventually drop to a lower energy state and release a photon. The time required for the event to occur, the specific final energy level, and the direction of the released photon cannot be determined or predicted, only the probabilities of the allowed outcomes.

29 Briggs, "Science, Religion Are Discovering Commonality in Big Bang Theory."

30 Sandage, "A Scientist Reflects on Religious Belief," 53.

31 In addition to panpsychism (see Ch. 13, n. 12), I'm often asked about whether the worldview or metaphysical hypothesis known as panentheism can explain the evidence concerning cosmological and biological origins discussed in this book. Panentheism comes in different varieties, but it's most commonly associated with the American philosopher and theologian Charles Hartshorne (see Hartshorn, *The Divine Relativity*). Like theism, panentheism, as developed by Hartshorne, holds that a personal God exists and that the physical universe depends upon God and can't exist without God. Nevertheless, unlike classical or biblical theism, Hartshorne's panentheism also affirms that God depends in some sense upon the universe and can't exist without it. Indeed, Hartshorne envisions the physical world and God as simultaneously "co-evolving."

Clearly, panentheism, as articulated by Hartshorn, would fail as an explanation for the origin of the universe itself. If God's existence depends upon the universe, then until the universe comes into existence, no God of the panentheistic variety would have yet existed. But since the universe appears to have come into existence a finite time ago, a panentheistic God could not have acted to cause the origin of that universe, since God's own existence depends upon the universe itself already existing.

Similarly, since the fine tuning of the universe has existed from the beginning of the universe, and since God as conceived by Hartshorn has no existence independent of the universe, a panentheistic God cannot be invoked as either a logically or temporally prior entity capable of causing or selecting the fine-tuning parameters that apply to the laws and constants of physics and the initial conditions of the universe. Instead, since God's existence, again, depends upon the universe, it is not clear that it could explain either the temporal beginning of the universe or the features of the universe that were set from the beginning.

A panentheistic God might be posited as part of a co-evolutionary process that produces new forms of life. Nevertheless, one could also argue that such a thesis fails the test of experience. We have a great breadth of experience showing that intelligent agents can and do generate specified information of the kind that is present in living systems. Nevertheless, we do not have experience of designing agents changing in their fundamental nature as the result of generating such information or designing technological objects. This may be more debatable, but once what I mean by "in their fundamental nature" is tightly defined, it appears to me to be a quite defensible statement.

In any case, panentheism as conceived by Hartshorn clearly cannot invoke a truly independent or transcendent intelligence as the cause of the origin and fine tuning of the universe and thus lacks explanatory power with respect to at least these two key facts in need of explanation. For a thorough exposition and critique of Hartshorn's panentheism, also known as process theology, see Richards, *The Untamed God*, 172–94. For a discussion of some contemporary classical theists who also use the term "panentheism" to describe their view of God, see Chapter 14, n. c, at www.returnofthegodhypothesis.com/extendedresearchnotes.

32 One objection to all theistic arguments in support of God's existence is the well-known problem of evil. Atheistic critics of theism pose this as what philosophers call a "defeater" argument. They contend that the existence of evil, both human moral evil and so-called natural evil, renders belief in the existence of God, or at least a benevolent God, logically incoherent—thus, "defeating" theistic arguments for God's existence. Atheists pose a familiar dilemma to support this claim: A benevolent and all-powerful God would not have allowed evil in the world. Since there *is* evil in the world, God is either not good, not all powerful or—more likely—does not exist.

Since at least the time of St. Augustine (or the writing of the book of Job), Christians, Jews, and other theists have answered this objection with the classical free will defense. They have insisted that the existence of human moral evil in the world is consistent with the existence of God if one considers, first, that God wanted to create human beings in God's own image with genuine free will; and second, that God clearly thought it better to make a world in which human beings could exercise their freedom, even if they might use it badly, rather than to create a world in which human beings were compelled as mere puppets to do only what God thought best. There is much to say about this philosophical and theological issue. Nevertheless, the free will defense has seemed to me and many theists a satisfactory response to the philosophical problem of evil. It certainly defeats the atheistic defeater argument of evil by showing that it is possible to reconcile belief in the existence of the omnipotence and benevolence of God with the presence of human moral evil in the world.

But what about the problem of natural evil or what is sometimes called "malevolent design" in nature? This argument has often seemed more troubling for theists and more difficult to answer. Atheists and scientific materialists have often pointed to the existence of virulent strains of bacteria or killer viruses as inconsistent with the existence of an intelligent designer, or at least a benevolent designer or creator. Answering this objection completely would take another book and lies beyond the scope of this work.

Nevertheless, I offer a few thoughts that I think can establish a framework for addressing the objection of natural evil and for showing that the existence of natural evil is not necessarily inconsistent with the theory of intelligent design, a larger God hypothesis, or even a belief in the existence of a benevolent designer or creator.

Clearly, the problem of natural evil only poses a problem for those who want to affirm, as I do, the benevolence of the designing intelligence responsible for life or a God such as the one the Judeo-Christian scriptures affirm. Nevertheless, those same Judeo-Christian scriptures, and what they teach about God and the created order, provide explanatory resources for reconciling the presence of natural evil in the world with the existence of a benevolent designer or creator. In other words, Judeo-Christian proponents of intelligent design have a framework for answering this objection that purely secular or nonreligious proponents of the theory of intelligent design may not.

Based on the Judeo-Christian scriptures, one should expect to find not one, but two classes of phenomena in nature. Indeed, one should expect to find evidence of intelligent design and goodness in the creation, but also evidence of subsequent decay and degradation.

Concerning the first expectation, the Judeo-Christian scriptures clearly affirm that

God's original design of the universe and life was "good" and even beautiful. And, of course, there are many such evidences of good design in living systems and the universe (see Chapters 7–10) and much beauty to enjoy in the natural world. Thus, a significant body of evidence supports the hypothesis that a benevolent intelligent creator designed the natural world.

Nevertheless, there are aspects of nature, particularly in the living realm, such as virulent strains of bacteria or viruses, that do not promote human flourishing, but instead disease and suffering. Yet, this too is not unexpected from the standpoint of a specifically Judeo-Christian version of theism or by proponents of intelligent design (or a larger God hypothesis) who hold this worldview. The Judeo-Christian scriptures not only teach that God created the world and pronounced it good; they also teach that something went wrong that adversely affected both the human moral condition and the natural order. The scriptures also provide a backstory, whether understood mytho-poetically or more strictly historically, explaining in part why and how this disruption to the original created order occurred.

In any case, based on the Judeo-Christian scriptures we should not only expect to see evidence of an intelligent and good original design, but also evidence of subsequent decay in nature and living systems. The entropy-maximizing (order-destroying) processes to which all physical systems are subject may well be considered evidence confirming this expectation. Moreover, at the molecular level in living systems, biologists are increasingly discovering evidence of both elegant aboriginal design—in, for example, the information-bearing biomacromolecules and information-processing systems in cells as well as the miniature machines and circuitry in cells and of the decay of those systems, often via mutations.

Intriguingly, microbiologists who study virulence increasingly recognize mutational degradation and loss of genetic information, or the lateral transfer of genetic information out of its original context, as the mechanisms by which virulent strains of bacteria emerge. [See, for example, Monday et al., "A 12-base-pair Deletion in the Flagellar Master Control Gene flhC Causes Nonmotility of the Pathogenic German Sorbitol-fermenting Escherichia coli O157:H-strains," 2319–27; Minnich and Rohde, "A Rationale for Repression and/or Loss of Motility by Pathogenic *Yersinia* in the Mammalian Host," 298–310.] Moreover, virulence experts document that such informational losses or transfers—losses or mutations that, from an intelligent design perspective, reverse or alter the original creative acts that made life possible—are responsible for the emergence of the harmful bacteria that cause human suffering. For example, *Yersinia pestus*, the microorganism that caused the plague, arose as the result of four or five identifiable mutations of various kinds during human history, altering an innocuous bacterium for which humans had an in-built immune response into a killer bug [Rasmussen et al., "Early Divergent Strains of *Yersinna pestus* in Eurasia 5000 Years Ago." 571–82]. As University of Idaho microbiologist Scott Minnich explained to me in a 2020 personal interview, "With molecular techniques and DNA sequencing we have in the last 10 years shown that the plague 'evolved'—or rather devolved—from an innocuous progenitor strain of bacteria."

Thus, just as the bursts of novel biological information that occur in the generation of new forms of life give evidence of the activity of a designing intelligence, the mutations that degrade or alter that information show subsequent processes of decay at work in living systems after their original design. That we see evidence of both good design and subsequent decay, and that we further recognize that processes of decay, not the aboriginal design of living systems, are responsible for human suffering, is precisely what we should expect to see based on a Judeo-Christian understanding of the natural world—a natural world that, as one biblical book puts it, is in "bondage to decay" (Rom. 8:21). Indeed, if the Judeo-Christian account is correct, we should positively *expect* to find tragic natural evils in the world around us. That expectation should temper any surprise we might otherwise have felt when, in fact, we do. Thus, our encounter with such natural evil actually provides evidential support for the Judeo-Christian understanding of nature considered as a kind of metaphysical hypothesis. It certainly shows that the existence of natural evil is not logically incompatible with belief in God. Those who argue otherwise fall into common logical fallacy. For a discussion of that fallacy, and how understanding it helps answer the atheistic argument from natural evil, see Chapter 14, n. d, at www.returnofthegodhypothesis.com/extendedresearchnotes.

Chapter 15: The Information Shell Game

1 Nagel, "Books of the Year."
2 Stephen Fletcher (December 4, 2009), *The Times Literary Supplement* 5566 (letter to the editor): 6.
3 Marshall, "When Prior Belief Trumps Scholarship."
4 Pera, *The Discourses of Science.*
5 Fletcher (December 4, 2009), *The Times Literary Supplement* 5566 (letter to the editor): 6.
6 Nagel, "Books of the Year."
7 Fletcher (December 4, 2009), *The Times Literary Supplement* 5566 (letter to the editor): 6.
8 Thomas Nagel (December 11, 2009), *The Times Literary Supplement* 5567 (letter to the editor): 6.
9 John Walton (December 11, 2009), *The Times Literary Supplement* 5567 (letter to the editor): 6.
10 Stephen Fletcher (December 18, 2009), *The Times Literary Supplement* 5568 (letter to the editor): 6.
11 Stephen C. Meyer (January 15, 2010), *The Times Literary Supplement* 5572 (letter to the editor): 6.
12 De Duve, *Blueprint for a Cell*, 187.
13 Powner, Gerland, and Sutherland, "Synthesis of Activated Pyrimidine Ribonucleotides in Prebiotically Plausible Conditions."
14 Lincoln and Joyce, "Self-Sustained Replication of an RNA Enzyme."
15 Stephen Fletcher (February 5, 2010), *The Times Literary Supplement* 5575 (letter to the editor): 6.
16 In February of 2010, I wrote another letter in response to Fletcher's third letter; the *TLS* did not publish it. They had understandably had enough!
17 Berlinski, "Responding to Stephen Fletcher's Views in *The Times Literary Supplement* on the RNA World."
18 Tour, "Animadversions of a Synthetic Chemist;" Tour, "Time Out"; see also Tour, "An Open Letter to My Colleagues."
19 Marshall, "When Prior Belief Trumps Scholarship."
20 Specifically, Marshall writes, "But today's GRNs have been overlain with half a billion years of evolutionary innovation (which accounts for their resistance to modification), whereas GRNs at the time of the emergence of the phyla were not so encumbered" ("When Prior Belief Trumps Scholarship").
21 According to Eric Davidson: "There is always an observable consequence if a dGRN subcircuit is interrupted. Since these consequences are always catastrophically bad, flexibility is minimal, and since the subcircuits are all interconnected, the whole network partakes of the quality that there is only one way for things to work. And indeed the embryos of each species develop in only one way" ("Evolutionary Bioscience as Regulatory Systems Biology," 40). See also the discussion in *Darwin's Doubt*, 264–70.
22 Peter and Davidson, *Genomic Control Processes.*

23 For a diagrammed schematic of the dGRN circuitry in the purple sea urchin, *Strongylocentrotus purpuratus*, see Fig. 13.4 in *Darwin's Doubt*, 266.
24 Davidson, "Evolutionary Bioscience as Regulatory Systems Biology," 38.
25 Davidson, "Evolutionary Bioscience as Regulatory Systems Biology," 38.
26 Davidson and Erwin, "An Integrated View of Precambrian Eumetazoan Evolution," esp. 72.
27 As Davidson notes, "Contrary to classical evolution theory, the processes that drive the small changes observed as species diverge cannot be taken as models for the evolution of the body plans of animals" (*The Regulatory Genome*, 195; "Evolutionary Bioscience as Regulatory Systems Biology," 35–36).
28 Davidson, "Evolutionary Bioscience as Regulatory Systems Biology," 40.
29 Marshall, "Nomothetism and Understanding the Cambrian 'Explosion'."
30 Marshall and Valentine, "The Importance of Preadapted Genomes in the Origin of the Animal Bodyplans and the Cambrian Explosion," esp. 1195–96.
31 Marshall, "Explaining the Cambrian 'Explosion' of Animals," 366.
32 Marshall and Valentine, "The Importance of Preadapted Genomes," 1189.
33 Meyer, *Darwin's Doubt*, 191.
34 See Shannon, "A Mathematical Theory of Communication."
35 Reidhaar-Olson and Sauer, "Functionally Acceptable Solutions in Two Alpha-Helical Regions of Lambda Repressor"; Axe, "Estimating the Prevalence of Protein Sequences Adopting Functional Enzyme Folds."
36 As it happens, recent comparative studies of the genetic diversity of the animal phyla have confirmed my original contention rather than Marshall's proposal. These studies have established that many thousands of novel genes did arise abruptly during the Cambrian explosion in order to build the first animals. As Jordi Paps and Peter Holland, the authors of one study, put it: "Contrary to the prevailing view, this [study] uncovers an unprecedented increase in the extent of *genomic novelty* during the origin of the metazoans," that is, during the period of or just before the appearance of the disparate body plans in the Cambrian explosion (emphasis added). The authors concluded that "internal genomic changes were as important as external factors in the emergence of animals" ("Reconstruction of the Ancestral Metazoan Genome Reveals an Increase in Genomic Novelty"). A similar study has recently confirmed the same pattern of explosive gene origination just before or coincident with the origin of land plants; see Bowles, Bechtold, and Paps, "The Origin of Land Plants Is Rooted in Two Bursts of Genomic Novelty."
37 Charles Marshall and Stephen Meyer debate on *Unbelievable* with Justin Brierley, November 30, 2013, https://www.youtube.com/watch?v=6yOCpb0wBPw. For a transcript of the relevant portions of this dialogue, see Chapter 15, n. a, at www.returnofthegodhypothesis/extendedresearchnotes.
38 Haarsma makes this claim in response to me in "Response from Evolutionary Creation" (224), her essay in the book *Four Views on Creation, Evolution, and Intelligent Design*, to which both she and I contributed.
39 Durston et al., "Measuring the Functional Sequence Complexity of Proteins"; Reidhaar-Olson and Sauer, "Functionally Acceptable Solutions in Two Alpha-Helical Regions of Lambda Repressor"; Taylor et al., "Searching Sequence Space for Protein Catalysts"; Yockey, "A Calculation of the Probability of Spontaneous Biogenesis by Information Theory."
40 Axe, "Estimating the Prevalence of Protein Sequences Adopting Functional Enzyme Folds."
41 Tokuriki and Tawfik, "Stability Effects of Mutations and Protein Evolvability"; Tokuriki et al., "The Stability Effects of Protein Mutations Appear to Be Universally Distributed"; see also Bershtein et al., "Robustness–Epistasis Link Shapes the Fitness Landscape of a Randomly Drifting Protein"; Lundin et al., "Experimental Determination and Prediction of the Fitness Effects of Random Point Mutations in the Biosynthetic Enzyme HisA."

42 Bechly, Miller, and Berlinski, "Right of Reply." See also Miller, "Protein Folding and the Four Horsemen of the Axocalypse." Miller, "A Dentist in the Sahara: Doug Axe on the Rarity of Proteins Is Decisively Confirmed."
43 Chiarabelli et al., "Investigation of De Novo Totally Random Biosequences, Part II"; Ferrada and Wagner, "Evolutionary Innovations and the Organization of Protein Functions in Sequence Space."
44 Venema, in: Venema and McKnight, *Adam and the Genome*, 85.
45 Venema, in: Venema and McKnight, *Adam and the Genome*, 85.
46 Venema, in: Venema and McKnight, *Adam and the Genome*, 85.
47 Negoro et al., "X-ray Crystallographic Analysis of 6-Aminohexanoate-Dimer Hydrolase."
48 Indeed, the close sequence identity between nylonase and its cousin suggests the genes for both proteins arose from a common ancestral gene, which also would have coded for a protein with nylonase activity. It follows that the mutations that produced the gene for nylonase did not generate a "brand-new" functional gene and protein, but instead merely optimized a *preexisting* function in a similar protein using the same fold. Kato et al., "Amino Acid Alterations Essential for Increasing the Catalytic Activity of the Nylon-Oligomer-Degradation Enzyme of *Flavobacterium* sp."
49 Negoro et al., "X-ray Crystallographic Analysis of 6-Aminohexanoate-Dimer Hydrolase."
50 It is worth pointing out that a close reading of Venema's critique shows that he does not understand protein structure. To see why, see Chapter 15, n. b, at www.returnofthe godhypothesis/extendedresearchnotes.
51 Dawkins, comment 14 in Coyne, "God vs. Physics."
52 For Moran's position, see Moran, "You Need to Understand Biology If You Are Going to Debate an Intelligent Design Creationist"; for Myers's postmortem, see Myers, "A Suggestion for Debaters."
53 Axe, "Estimating the Prevalence of Protein Sequences."
54 See Meyer, *Darwin's Doubt*, 292–335, and Meyer, *Signature in the Cell*, 272–323.

Chapter 16: One God or Many Universes?

1 In inflationary cosmology, the production of bubble universes was a natural consequence of the quantum character of the proposed inflationary mechanism. Once this was realized, however, this feature of the model was put to use to explain away initial-condition fine tuning. String theory had a similarly innocuous origin as well—first as an attempt to develop a theory of the strong nuclear interaction and then as a promising candidate for a "theory of everything"—before being appropriated as an explanation for the fine tuning of the laws and constants of nature.
2 I've chosen, by the way, to defer addressing these other more abstract possible explanations till now for two reasons. First, I wanted to give readers a chance to see just how unexpected the main discoveries about the complexity of life and the origin and fine tuning of the universe really are from a standard naturalistic or materialistic point of view—and thus to feel the force of the core case for theism as a better explanation than the most "natural" forms of naturalism. Second, I wanted to leave some of the more difficult concepts and technical material to this final section of the book to allow readers who feel they've already gone deep enough the opportunity to skim or skip these chapters and other, more technically minded readers the opportunity to dig deeper and evaluate the strength of my case for theism against even the most exotic naturalistic cosmologies and theories.
3 *Lexico*, https://en.oxforddictionaries.com/definition/exotic.
4 Recall that physicists disagree about how precisely to define these different models. See my discussion about these semantic differences in Chapter 8, nn. 26, 28, and 29. See also Barrow, "Anthropic Definitions," 150; Barrow and Tipler, *The Anthropic Cosmological*

Principle, 16–25; Carter, "Large Number Coincidences and the Anthropic Principle in Cosmology," 291–98; Lewis and Barnes, *A Fortunate Universe*, 19.

5 Science writer Clifford Longley explains the concept this way: "There could have been millions and millions of different universes created each with different dial settings of the fundamental ratios and constants, so many in fact that the right set was bound to turn up by sheer chance" ("Focusing on Theism").

6 A few physicists have proposed that if our bubble universe bumped into another bubble universe, it would leave detectable patterns in the CMBR (Sokol, "A Brush with a Universe Next Door"). Roger Penrose has made a similar claim for his conformal cyclic cosmology (CCC) model in which the universe goes through infinitely many cycles with the future time-like infinity of each earlier iteration being identified with the big bang singularity of the next (for a popular account, see his book *Cycles of Time: An Extraordinary New View of the Universe*). He argues that observed "hot spots" in the CMBR represent evidence of interaction between the different modes of the universe in its collapsing and expanding phases. Specifically, he sees hot spots in the CMBR as evidence of the collapse of black holes prior to the beginning of our universe in its present expansion phase ("On the Gravitization of Quantum Mechanics 2"). Even so, his model does not, strictly speaking, represent a multiverse model, since the universes exist in succession, not in parallel.

7 Linde, "A New Inflationary Universe Scenario"; Guth, "Inflationary Universe"; Albrecht and Steinhardt, "Cosmology for Grand Unified Theories with Radiatively Induced Symmetry Breaking."

8 Linde, "Eternally Existing Self-Reproducing Chaotic Inflationary Universe."

9 Stenger, "Fine-Tuning and the Multiverse."

10 Physicists and philosophers call this an "observer selection effect." By this they mean we necessarily must observe a universe with features compatible with complex life forms and thus should not be surprised to find ourselves in such a universe—especially if the multiverse correctly depicts reality and various universe-generating mechanisms will eventually produce some life-permitting universe somewhere.

11 String theory was first proposed in the late 1960s to describe the strong nuclear force. Another approach, known as quantum chromodynamics, eventually proved more effective for that task, however. Then, in the 1970s, Caltech physicist John Schwarz and others noticed that string theory held promise for reconciling general relativity with quantum mechanics. That realization generated renewed interest in developing the theory.

12 Manoukian, "Introduction to String Theory."

13 The earliest version of string theory offered only a description of the bosons that carry the strong nuclear force, and it required twenty-six-dimensional spacetimes in order to work. So as initially formulated, string theory was bosonic and twenty-six-dimensional and could not account for the existence of matter! What Schwarz and his collaborators discovered as they continued to work on the theory in the 1980s was a way to extend string theory to include all matter and radiation. For a short discussion of how they did this, see Chapter 16, n. a, at www.returnofthegodhypothesis/extendedresearchnotes.

14 Dimopoulos, "Splitting Supersymmetry in String Theory."

15 Susskind, "The Anthropic Landscape of String Theory."

16 Bena and Graña, "String Cosmology and the Landscape."

17 Bousso and Polchinski, "The String Theory Landscape."

18 This postulation is highly dubitable, since there is no way of knowing how much of the string landscape will get explored by such a means. There is no *a priori* reason to suppose the process of exploring the landscape will be complete. But if it isn't significantly complete, it's unlikely that cascading down the energy landscape will generate a universe like ours. In addition, Baylor University engineering professor and information theorist Robert Marks has recently challenged the idea that the inflationary string-theory multiverse produces enough universes to generate enough "contradistinctions" to render

the fine tuning in our universe probable. See Marks, "Diversity Inadequacies of Parallel Universes."

19 Ellis, "Cosmology." Readers familiar with my previous work in the philosophy of science will know that I don't think a bright line of demarcation between science and metaphysics can be drawn. Consequently, I don't think it's justified to disregard or reject a hypothesis simply because it may invoke philosophical or metaphysical ideas. We may by convention classify such hypotheses as metaphysical, but that does not mean they are necessarily false, insignificant, untestable, or beyond rational evaluation. For an extended discussion of the so-called demarcation issue and its applicability to assessing an intelligent design and/or a God hypothesis, see Chapter 16, n. b, at www.returnofthe godhypothesis/extendedresearchnotes. See also Meyer, "Sauce for the Goose"; "The Scientific Status of Intelligent Design"; "The Demarcation of Science and Religion."

20 As George Ellis has argued, "So one can motivate multiverse hypotheses as plausible, but they are not observationally or experimentally testable—and never will be. It is easy to support your favourite model over others because no one can prove you wrong—you can simply adjust its parameters to fit the latest information" ("Cosmology," 295).

21 Swinburne, *The Existence of God*, 185.

22 Swinburne, *The Existence of God*, 185.

23 For a popular account of this process, see Bousso and Polchinski, "The String Theory Landscape." For a more extended popular treatment, see Susskind, *The Cosmic Landscape*.

24 Gordon, "Postscript to Part One"; "Balloons on a String."

25 These points are explicit in a set of unpublished lecture notes that Gordon has shared with me, but implicit in a variety of Gordon's publications, for example, "Balloons on a String" and "Divine Action and the World of Science."

26 One version of string theory—known as the "cyclic ekpyrotic model"—does attempt to explain the fine tuning of both the initial conditions and the laws and constants of physics without invoking inflation. Yet it too offers a bloated ontology measured by the number of entities it must invoke to explain these two different kinds of fine tuning. For an explanation of this defect in the "cyclic ekpyrotic model," see Chapter 16, n. c, at www.returnofthegodhypothesis/extendedresearchnotes.

27 Collins, "The Fine-Tuning Design Argument."

28 Interview with Robin Collins in Strobel, *The Case for a Creator*, 178.

29 The energy associated with the inflaton field—in particular, something called the "inflation-preheating coupling parameters" required to convert inflationary energy to normal mass-energy—is also reverse-engineered (fine-tuned) by physicists modeling the origin of the universe to produce a universe similar to ours in which life would be possible (see, e.g., Kofman, "The Origin of Matter in the Universe"; DeCross et al., "Preheating after Multifield Inflation with Nonminimal Couplings."

30 Carroll and Tam, "Unitary Evolution and Cosmological Fine-tuning."

31 Rees, *Just Six Numbers*, 115.

32 Page, "Inflation Does Not Explain Time Asymmetry."

33 Personal interview with Bruce Gordon, Seattle, July 18, 2019.

34 As allowed by quantum mechanics, individual bubble universes may occasionally "tunnel" through a potential energy barrier to a higher-energy universe that will in turn expand and then either decay or tunnel, generating yet more universes. Nevertheless, such tunneling events are extremely improbable, or "exponentially suppressed," as some theoretical physicists put it (see Linde, "Sinks in the Landscape, Boltzmann Brains and the Cosmological Constant Problem"). For a popular account of the whole process of "exploring the landscape," see Bousso and Polchinski, "The String Theory Landscape." For a more extended popular treatment, see Susskind, *The Cosmic Landscape*.

35 Smolin, *The Trouble With Physics*, xiv.

36 Gordon, "Balloons on a String," 580–81.

37 Kallosh, Kofman, and Linde, "Pyrotechnic Universe."

38 Kallosh, Kofman, and Linde, "Pyrotechnic Universe."

39 Collins, "The Fine-Tuning Design Argument," 61; see also "The Multiverse Hypothesis." Some cosmologists might argue that even the prior sources of fine tuning presupposed in the inflationary string landscape model can be explained simply by positing a mechanism for generating an infinite number of universes with different inflaton fields and shutoff parameters. To do so, they might first envision each string vacua in the landscape producing an inflaton field. They could then envision that each of these different inflaton fields would be subject to random quantum fluctuations that will produce different fields with different shutoff energies and intervals. Each such fluctuation would then produce a new universe, though in all probability not a life-conducive one. Nevertheless, if (1) an *infinite* number of such fluctuations occurred in (2) an infinite space produced from (3) an infinite singularity within either a hyperbolic or flat universe, *then* an actually infinite number of different universes would emerge, some of which would have correct inflaton shutoff energies and intervals to ensure the production of many life-conducive universes. Thus, some might argue that such an "infinite-verse" could explain the prior fine tuning of the inflaton field—if, again, one posited an infinite number of random quantum fluctuations producing an infinite number of universes with different inflaton fields and shutoff parameters. If an infinite number of universes and inflaton fields will inevitably arise, then the fine tuning required for a life-conducive universe will eventually emerge.

This speculative scenario depends upon several contestable assumptions (enumerated as 1-3 above) and does not, in any case, actually circumvent the need for prior fine tuning. Indeed, the inflaton field necessary to the universe-generating mechanism of the inflationary string landscape requires several sources of built-in fine tuning that *precede* the mechanism for producing any new bubble universes.

For example, proponents of the inflationary multiverse (and the combined string inflationary multiverse) make a number of gratuitous assumptions about the structure of our universe in order to get inflationary cosmology to mesh with general relativity. Moreover, they *must* do this because the mechanism that produces bubble universes presupposes general relativity. Thus, proponents of these models have to make specific assumptions about the nature of spacetime and reject others (Penrose, "Difficulties with Inflationary Cosmology"; The Road to Reality, 757). That's in part because there's no guarantee that any given inflaton field, when conjoined with general relativity, will actually produce inflation (Hawking and Page, "How Probable Is Inflation?"). Consequently, physicists have to select some inflationary models and exclude others based on whether they would allow inflation to occur and bubble universes to form. But this implies fine tuning in the structure of spacetime, a fine tuning that precedes the operation of any specific mechanism that could generate new universes.

In addition, explaining the homogeneity of the universe using inflaton fields also requires built-in fine tuning. To explain the homogeneity of the universe using inflationary cosmology physicists have to make assumptions about the singularity from which everything came. As Roger Penrose has pointed out, however, if the singularity were perfectly generic, expansion from it could yield many different kinds of irregular (inhomogeneous) universes, even *if* inflation had occurred ("Difficulties with Inflationary Cosmology"). Thus inflation alone, without additional assumptions about the singularity (and a corresponding "spacetime metric"), does not solve the homogeneity problem.

(For a discussion of the cosmic "chicken and egg" problem this objection to my argument creates, see Chapter 16, n. d, at www.returnofthegodhypothesis/extended researchnotes.)

Further, though the inflaton field may be conceived to generate an infinite number of universes, it doesn't generate enough of the right kind. As noted, though the decay of the inflaton field may produce bubble universes with many new initial conditions, it does not produce new universes with new laws and physical constants. Consequently, the inflationary string landscape model must rely on the string-theoretic generating mechanism to do that.

Nevertheless, the process of "exploring the landscape" will not itself produce an infinite number of new universes, but instead only a finite number corresponding to—at most—the number of solutions to the string-theoretic equations that have a positive cosmological constant. Moreover, nothing in string theory guarantees an exhaustively random search of that finite number of possible universes in the landscape. At best, the process of "cascading down the landscape" will explore a large number of those possible universes but only if the process starts with an initial high-energy compactification. But such a condition implies exquisite initial-condition fine tuning, as noted on page 339. And that fine tuning—fine tuning that may still only make a limited search through the landscape possible—necessarily precedes such a search (and precedes the generation of new bubble universes as envisioned in the combined model).

In addition, significant additional fine tuning is built into string theory itself, implying—if string theory accurately represents the universe—the existence of additional sources of fine tuning in the universe. In the late 1990s, string theorists found in their modeling that if they wrapped lines of flux around the compactified dimensions of space, they could stabilize them and ensure their continued compactification. They also found that lines of flux could only be wrapped around the compactified dimensions of space a limited number of times before they became unstable again, but that "tying them down" in specific ways ensured that the corresponding compactifications had a positive cosmological constant, thus matching a key physical feature of our universe. That string theory requires such a precise selection of parameters in order for its solutions to match the physics of our universe shows that the universe as described by string theory has contingent features that must be finely tuned to produce a universe like ours. And this implies that if string theory accurately depicts the universe, additional kinds of unexplained fine tuning must be built into it and the universe it putatively describes.

Consequently, even if the inflationary string multiverse could produce an infinity of universes, it still leaves unexplained many significant sources of prior fine tuning, a fine tuning that precedes the operation of a specific mechanism for generating new universes.

Beyond all this, inflationary cosmology presupposes fine tuning in the structure of the laws of physics themselves, a fine tuning that turns out to be a necessary condition of an efficacious inflaton field. As Robin Collins and Bruce Gordon have pointed out, the inflaton field depends upon many specific laws of physics that could exhibit different mathematical structures or relationships. For example, the mechanism for generating bubble universes depends upon a mechanism for translating energy into mass. Thus, it presupposes a universe operating in accord with Einstein's famous equation $E = mc^2$. Yet conceivably many other such mathematical relationships (or none whatsoever) might govern the relationship between mass and energy, many of which would preclude the operation of the kind of universe-generating mechanism that inflationary cosmology envisions.

Similarly, both Gordon and Collins point out that the inflationary universe-generating mechanism depends upon a larger built-in and finely tuned law structure that includes: Einstein's field equations of general relativity, something like the Pauli exclusion principle (to allow the formation of complex chemical structures), and a principle of quantization governing all physical fields to permit the stability of matter (see n. 5, Chapter 7, p. 469). Though we rarely think about the possibility of different laws and physical principles governing our universe, such built-in mathematical laws and structures represent a type of fine tuning that would have to precede the operation of the inflationary universe-generating mechanism. Indeed, since inflationary cosmology's universe-creating mechanism does not generate universes with new laws or constants of physics, but instead only new initial conditions, it does not explain the fine tuning of the law structure of the universe. See Collins, "The Teleological Argument," 264; Gordon, "Postscript to Part One," esp. 97; "Balloons on a String."

40 Ijjas, Steinhardt, and Loeb, "Pop Goes the Universe."

41 For example, the uniform distribution of the wavelengths of the cosmic background radiation may be a consequence of inflation. But physicists can just as easily explain the uniformity of this distribution on straightforward mathematical grounds without reference to any cosmological model whatsoever. As Bruce Gordon notes, "The Gaussian (normal) distribution prediction of inflation is a straightforward consequence of the Central Limit Theorem, which states that the mean of a sufficiently large iteration of random variables with well-defined means and variances will have a near-normal distribution" ("Divine Action and the World of Science," 270). For an elaboration, see Peacock, *Cosmological Physics*, 342, 503.

42 Jogalekar, "Why the Search for a Unified Theory May Turn Out to Be a Pipe Dream."

43 For an extensive discussion of the key predictions of inflationary cosmology and why they fail, see Chapter 16, n. c, at www.returnofthegodhypothesis/extendedresearchnotes. See also Ijjas, Steinhardt, and Loeb, "Pop Goes the Universe," 37.

44 Oddly, inflationary cosmology also suffers from the opposite problem as well. Many of the evidences it explains or the predictions it makes can be explained or have been predicted on the basis of other models. For a discussion of how other cosmological models make the same predictions as the inflationary multiverse, see Chapter 16, n. e, at www.returnofthegodhypothesis/extendedresearchnotes.

45 Several leading physicists have suggested that postulating an inflaton field seems an increasingly contrived explanation for a range of cosmological evidence, in part because the field has to be highly gerrymandered to account for recent anomalies and failed predictions and in part because such fields represent purely hypothetical entities with idiosyncratic attributes. Indeed, inflaton fields, with their uncanny ability to activate the rapid expansion of space and then decay at just the right time in one model (between 10^{-37} to 10^{-35} seconds after the big bang) and in just the right measure, have properties associated with no other physical fields.

In addition, to accommodate recent failed predictions about gravity waves and the cosmic background radiation, inflationary cosmologists have had to revise their models of inflaton fields in extremely idiosyncratic ways, casting further doubt on the existence of these fields. Proponents of inflation now posit sudden, discontinuous, and/or irregular changes in the energy density of space as well as in the other parameters that affect the overall strength of the inflaton field. Proponents of inflation have also arbitrarily made adjustments to the mathematical function that relates the energy density of space and the strength of the field. These functions no longer define smooth curves as they did in the original models of Guth, Linde, and Steinhardt, but instead freakishly irregular curves that Steinhardt now describes as "arcane" and "contrived." The choice of inflation (energy) potential is essentially reverse-engineered to fit the data and then put forward as an "explanation" for what is observed (Ijjas, Steinhardt, and Loeb, "Pop Goes the Universe"). As the theoretical physicist William Unruh observed, "I'll fit any dog's leg that you hand me with inflation" (referenced in Holder, *God, the Multiverse, and Everything*, 130).

46 Ijjas, Steinhardt, and Loeb, "Pop Goes the Universe," 36.

47 Note that supersymmetry cuts both ways: it is not just that regular bosons have fermionic superpartners, but if they do, then the regular fermions have bosonic superpartners as well. What string theory requires is not just fermionic supersymmetric particles, but bosonic ones as well. In any case, experimental evidence for supersymmetry (whether by discovery of a supersymmetric boson or fermion) is a necessary but insufficient condition for the correctness of string theory. Yet *neither* supersymmetric bosons *nor* supersymmetric fermions have yet been detected in expected energy ranges, even though the energy scales have been adjusted upward multiple times. Given that supersymmetry is a necessary condition of the correctness of string theory, failure to detect either (by *modus tollens*) strongly disconfirms the theory.

48 Horgan, "Why String Theory Is Still Not Even Wrong."

49 Hooft, *In Search of the Ultimate Building Blocks*, 163–64. Or as physicist Lee Smolin has noted, "If string theory is to be relevant at all for physics, it is because it provides evidence for the existence of a more fundamental theory. This is generally recognized, and the fundamental theory has a name—M-theory—even if it has not yet been invented" (*The Trouble with Physics*, 182).
50 Quoted in Gefter, "Is String Theory in Trouble?"
51 Carr, "Introduction and Overview," 16.
52 Lewontin, "Billions and Billions of Demons," 31.

Chapter 17: Stephen Hawking and Quantum Cosmology

1 Hawking and Penrose, "The Singularities of Gravitational Collapse and Cosmology."
2 Hawking and Ellis, *The Large Scale Structure of Space-Time*.
3 Hawking and Ellis, *The Large Scale Structure of Space-Time*, 363.
4 "Has Hawking Explained God Away?"
5 Hawking, *A Brief History of Time*, 138.
6 Hartle and Hawking, "Wave Function of the Universe," 2960–75.
7 In fact, it's a bit more accurate to say that Hawking *effectively* introduced the $i\tau$ term into the spacetime metric because he first introduced the $i\tau$ term into a functional integral that includes the spacetime metric within its mathematical structure.
8 Calculating the probabilities for different states of the universe required him to construct integrals that could not be solved using real time, but could be solved using imaginary time. Wiltshire, "An Introduction to Quantum Cosmology," 488.
9 The time variable in complex analysis is plotted on an axis for imaginary time that has no physical meaning.
10 Hawking, "The Beginning of Time."
11 Hawking, *A Brief History of Time*, 140–41.
12 Another version of the cosmological argument known as the "cosmological argument from contingency" does not depend upon the universe having a beginning. It affirms, first, that the universe has many contingent features that could be otherwise, and one of those contingent facts about the universe is that it exists. Proponents of this argument contend that the existence of the universe is a contingent fact because it is logically possible that the universe might *not* exist. They also argue that every contingent fact must have a sufficient reason for its existence. Proponents further contend that the universe itself (and in some versions, the contingent relationships within it) cannot depend for its (or their) existence on any contingent fact within the universe. Instead, the universe must depend upon some necessarily existing cause—some cause that must exist independent of the universe, whether the universe began a finite time ago or not. The eighteenth-century German philosopher and mathematician Gottfried Leibniz summarized the argument as follows: "the sufficient or final reason must be outside of the succession or *series* of this diversity of contingent things [i.e., in the universe], however infinite it may be. Thus the final reason of things must be in a necessary substance . . . and this substance we call *God.*" (Leibniz, *The Principles of Philosophy Known as Monadology*). Prominent proponents of versions of the argument from contingency have not only included Leibniz, but also Thomas Aquinas and the capable contemporary philosophers Alexander Pruss of Baylor University and Andrew Loke of Hong Kong Baptist University. Pruss, *The Principle of Sufficient Reason*; "The Leibnizian Cosmological Argument"; Loke, "God and Ultimate Origins."
13 Craig and Sinclair, "The Kalām Cosmological Argument," p. 177–78, 179, Craig, *Reasonable Faith*, 109–113; Peacock, *A Brief History of Eternity*.
14 Hawking, *A Brief History of Time*, 139.
15 See n. 9 above.

16 Hawking does acknowledge that imaginary numbers have no real-world referent. Nevertheless, he also seems to make a weak attempt at justifying his decision to treat his mathematical depiction of the universe using imaginary time as if it told us something about the real universe—in particular, that the universe had no temporal beginning. In his 2001 book *The Universe in a Nutshell*, Hawking observes that "one might think . . . that imaginary numbers are just a mathematical game having nothing to do with the real world. From the viewpoint of positivist philosophy, however, one cannot determine what is real. All one can do is find which mathematical models describe the universe we live in" (p. 56). His argument here seems to be that since science doesn't *ever* tell us what is real about the world, but only produces models of it, it is perfectly acceptable to model the universe with a form of mathematics that can have no possible application to the real world. Perhaps so, but since Hawking has already affirmed that nothing in mathematical physics tells us about the real universe but only gives us models (positivism), he undercuts any claim to have produced a specific model that accurately depicts the real universe. If models in general don't tell us what is real, then his specific model using imaginary time doesn't either. Indeed, by proclaiming himself a positivist in his philosophy of science, he eschews all realist interpretations of mathematical physics, including any that depict a universe without a beginning in time.

17 Hawking, *A Brief History of Time*, 139.

18 Time has an inherent directionality in our universe; thus our use of descriptive words to describe it such as "before" and "after." By "spatializing time," Hawking's mathematical transformation rendered time directionless mathematically and thus inapplicable to spacetime in our universe.

19 Hawking, *A Brief History of Time*, 136.

20 Page, "Susskind's Challenge to the Hartle-Hawking No-Boundary Proposal and Possible Resolutions," 4.

21 Craig, "The Ultimate Question of Origins." See also Spitzer, *New Proofs for the Existence of God*; Copan and Craig, *Creation Out of Nothing*; Craig, *The Kalām Cosmological Argument*; *The Cosmological Argument from Plato to Leibniz*.

22 Vilenkin, "Quantum Cosmology and the Initial State of the Universe"; *Many Worlds in One*.

23 Mlodinow, "The Crazy History of Quantum Mechanics."

24 Vilenkin and Yamada, "Tunneling Wave Function of the Universe," 066003.

25 Huygens, *Treatise on Light*.

26 Young, "Bakerian Lecture."

27 Hertz, "Über den Einfluss des ultravioletten Lichtes auf die electrische Entladung."

28 "Photoelectric Effect," *The Physics Hypertext*, https://physics.info/photoelectric.

29 Einstein, "Über einen die Erzeugung und Verwandlung des Lichtes betreffenden heuristischen Gesichtspunkt."

30 To read more about what Einstein had to say about the particle-like quality of light, see Chapter 17, n. a, at www.returnofthegodhypothesis/extendedresearchnotes. See also Einstein, "Über einen die Erzeugung und Verwandlung des Lichtes betreffenden heuristischen Gesichtspunkt."

31 Taylor, "Interference Fringes with Feeble Light."

32 Taylor, "Interference Fringes with Feeble Light."

33 Davisson, "The Diffraction of Electrons by a Crystal of Nickel." (Don't forget the experiments of G. P. Thomson as well: "Experiments on the Diffraction of Cathode Rays.")

34 "What Is the Schrödinger Equation, Exactly?" *YouTube*, July 6, 2018, https://www.youtube.com/watch?v=QeUMFo8sODk&t=7s. See also Schrödinger, "An Undulatory Theory of the Mechanics of Atoms and Molecules."

35 Born, "Zur Quantenmechanik der Stoßvorgänge." See N. P. Landsman, "The Born Rule and Its Interpretation," http://www.math.ru.nl/~landsman/Born.pdf.

36 The known constant e is the base of the natural logarithm.

37 The function ψ is called a *wave* function because it determines a unitless amplitude that

yields a probability distribution that, in turn, describes the likelihood of the photon being observed at a particular location (or having a particular momentum) over time.

38 The interpretation that the wave function does not represent a real entity is the most popular interpretation. Nevertheless, some theoretical physicists have proposed interpretations in which it does represent a physical wave (Matzkin, "Realism and the Wavefunction").

39 Feynman, *The Character of Physical Law*, 129.

40 Though the observer-caused interpretation of the collapse of the wave function is now associated with Niels Bohr and called "the Copenhagen interpretation" in his honor, John von Neumann and Eugene Wigner originally proposed this interpretation. Moreover, Bohr himself believed that the formalism of quantum mechanics presupposed a classical world picture. Consequently, he did not actually advance the observer-induced collapse of the wave function idea that has been attributed to him. For more on how Bohr himself interpreted quantum phenomena (i.e., the collapse of the wave function), see Chapter 17, n. b, at www.returnofthegodhypothesis/extendedresearchnotes. See also Faye, "Copenhagen Interpretation of Quantum Mechanics"; Halvorson, "Complementarity of Representations in Quantum Mechanics"; "The Quantum Experiment That Broke Reality."

41 Quoted in Heisenberg, *Physics and Beyond*, 206.

42 In its mathematical analogy to the Schrödinger equation, the Wheeler-DeWitt equation uses Paul Dirac's procedure for quantizing the dynamical equations of spacetime geometry in general relativity (called a Hamiltonian constraint) in an effort to describe the quantum evolution of geometries in superposition.

43 Cooke, "An Introduction to Quantum Cosmology."

44 In reality, the standard universal wave function includes "matter fields" that will ultimately result in the production of different possible configurations of matter and energy. For simplicity's sake, however, I will refer to different possible curvatures and configurations of matter (or mass-energy) when discussing the possible pairings that determine the gravitational fields of different possible universes in quantum cosmology.

45 In ordinary quantum mechanics the wave function assigns probabilities, via a relationship called the Born Rule, named for the German physicist Max Born, to each possible value in the probability distribution described by the wave function ψ. Similarly, the solution to the Wheeler-DeWitt equation—the *universal* wave function ψ—assigns, via the Born Rule, probabilities to each possible value in the probability distribution described by ψ. The Born Rule specifies that probabilities for each possibility in superspace are calculated by squaring the absolute value of the probability distribution ψ. Once a variety of restrictive and simplifying assumptions are made, ψ allows physicists to calculate the probabilities associated with the different possible spatial geometries and configurations of mass-energy—the different possible universes—as they exist in superposition as described by ψ. In practice, the calculation of probabilities can be more complex. (Wiltshire, "An Introduction to Quantum Cosmology," 496–98.)

46 Butterfield and Isham, "Spacetime and the Philosophical Challenge of Quantum Gravity."

47 In reality, Hawking and Hartle first calculated a "ground-state wave function" that does not even include universes such as ours, as they acknowledge in their technical paper. In ordinary quantum mechanics, the ground-state wave function describes an electron in its lowest energy state. Knowing this wave function allows physicists to calculate the probability that an electron in its lowest orbital resides at a specific place, including at the center of the atom. By analogy, in quantum cosmology, the ground-state universal wave function allows quantum cosmologists to calculate the probability that any given universe, including a universe with zero spatial volume, will emerge out of the superposition of possible universes described by the wave function. As it turns out, Hawking and Hartle's ground-state wave function only describes *closed* universes, while our universe is an open universe (meaning it will expand indefinitely into the future). Thus, to explain how our universe arose from the universal wave function that they

calculate, Hawking and Hartle had to first calculate an "excited-state" wave function from their original "ground-state" wave function. That excited-state wave function also initially included only closed universes, some of which could "tunnel" into continuously expanding universes such as ours. In this way, they "explained" the origin of our universe.

48 Technically, Hawking and Hartle's initial solution to the Wheeler-DeWitt equation did not itself include a universe like ours. See n. 47.

49 Their model does not eliminate a spatial singularity, however. Hawking and Hartle still assume a spatial singularity in what they call a "zero three-geometry" ("Wave Function of the Universe," 2961).

50 Indeed, prior to their use of the Wick rotation to solve the Wheeler-DeWitt equation (or rather the specific path integral they solved in its place), Hawking and Hartle first presuppose an actual spacetime singularity out of which various possible universes could have emerged. As they noted in their technical paper, "One can interpret the functional integral over all compact four-geometries bounded by a given three-geometry as giving the amplitude for that three-geometry to arise from a zero three-geometry, that is, a single point. In other words, the ground state is the amplitude for the Universe *to appear from nothing*" ("The Wave Function of the Universe," 2961).

51 Note, again, that our universe actually represents a continually expanding universe, but Hawking and Hartle's initial solution to the Wheeler-DeWitt equation included only closed universes. See n. 47.

52 See n. 47 for important qualifications.

Chapter 18: The Cosmological Information Problem

1 Krauss, "Ultimate Issues Hour: How Does Something Come from Nothing?," interview on *The Dennis Prager Show*, January 29, 2013.

2 "Ultimate Issues Hour: Evolution Revolution," interview on *The Dennis Prager Show*, October 16, 2018.

3 Vilenkin, "Creation of Universes from Nothing."

4 Borde and Vilenkin, "Eternal Inflation and the Initial Singularity"; Borde and Vilenkin, "Violation of the Weak Energy Condition in Inflating Spacetimes"; Borde, Guth, and Vilenkin, "Inflationary Spacetimes Are Incomplete in Past Directions."

5 For a very recent discussion and expansion of Vilenkin's model, see Vilenkin and Yamada, "Tunneling Wave Function of the Universe."

6 Krauss, *A Universe from Nothing*, 159. The statement is not actually original to Krauss. It can be traced back to a remark made by the Nobel laureate Frank Wilczek in a *Scientific American* article on matter-antimatter symmetry that he wrote back in 1980: "The answer to the ancient question 'Why is there something rather than nothing?' would then be that 'nothing' is unstable" ("The Cosmic Asymmetry Between Matter and Antimatter"). This quote has also appeared repeatedly in new atheist literature (see, e.g., Stenger, *God: The Failed Hypothesis*, 133).

7 Hawking and Mlodinow, *The Grand Design*, 180.

8 Krauss, *A Universe from Nothing*, 161–70.

9 Krauss, *A Universe from Nothing*, 169.

10 Krauss, *A Universe from Nothing*, 142.

11 For a good, concise, and accessible introduction to these topics, see Baggott, *The Quantum Story*, 361–71. For a discussion of the ill-defined, intractable nature of the Wheeler-DeWitt equation and its interpretation, see Butterfield and Isham, "On the Emergence of Time in Quantum Gravity," esp. 43–62 (secs. 5.2–5.5). Comprehensive technical introductions can be found in Bojowald, *Quantum Cosmology*, and Rovelli, *Quantum Gravity*. An examination of some of the philosophical implications of quantum gravity and quantum cosmology can be found in Callender and Huggett, eds., *Physics*

Meets Philosophy at the Planck Scale. See also Bojowald, Kiefer, and Moniz, "Quantum Cosmology for the XXIst Century: A Debate"; Gordon, "Balloons on a String," esp. 563–69; Kiefer, "The Need for Quantum Cosmology"; "Conceptual Problems in Quantum Gravity and Quantum Cosmology"; and Rovelli, "The Strange Equation of Quantum Gravity."

12 And, of course, there are even deeper questions here. Why is conservation of momentum one of the "laws" of nature in the first place, and what does it mean for something to be a natural "law"? It is certainly *not* a "law" on the grounds of it being a logical or metaphysical necessity—there is no absurdity that would result from its denial—so why is this regularity there in the first place and what maintains it?

13 Actually, there are two ways of understanding ψ, and neither specifies a material cause of the universe. One implies that ψ does not represent a definite state of affairs with material existence prior to the emergence of one of these possible universes. The universal wave function is *not a material entity* or even an energy-rich field in a real space. It only represents an information-rich mathematical expression describing different possibilities. The universal wave function, in this view, is just a mathematical expression that makes possible assigning differing probabilities to different possible universes. These probabilities are just artifacts of the mathematical calculating procedure that generates them. They do not correspond to actual material universes existing simultaneously or "in superposition" with one another. Consequently, ψ does not describe or specify any *thing* that could act as the cause of any particular outcome—that is, any particular universe. Nor does any material antecedent precede the universal wave function that could do so.

In another interpretation of the universal wave function, ψ does represent an actually existent universe, as opposed to a merely mathematical reality, albeit one in which many different possible universes with different possible gravitational fields exist simultaneously "in superposition." Nevertheless, even in this interpretation, nothing about that universe (or those universes) in that indeterminate state causes one, rather than another, of the possibilities to emerge as our universe. Instead, each of those different possible universes exists in parallel and in isolation from the others, and none of them in any way causes the others to materialize. Nor does any material antecedent determine the probability of the possible universes described by ψ. Instead, how the *physicist chooses* to solve the Wheeler-DeWitt equation determines the resulting ψ function and, thus, those probabilities. Thus, this interpretation of the wave function does not specify a material antecedent as a cause of our universe either. Nor does it provide a causal explanation for the origin of any of the universes that ψ describes as putatively existing in superposition.

14 Put another way, ψ describes a *necessary* condition for a universe to come into being—namely, that a particular universe is one of the possibilities included in the universal wave function. It doesn't describe a *sufficient* condition for that universe's arising, however. Thus, ψ doesn't specify the cause of the origin of any particular universe, much less actually cause its ultimate origin. Even so, another popular interpretation of the universal wave function tries to solve this problem. It holds that every spatial geometry and configuration of matter (matter field) described by the universal wave function does exist as a separate universe "in some possible world." This many-worlds interpretation (MWI) of quantum mechanics and quantum cosmology does not, however, specify a cause of the existence of these universes or, for that matter, our own. Instead, it represents an interpretation of what the wave function describes without addressing the underlying question of causation. See the next chapter, Chapter 19, for an extensive discussion of the MWI.

15 In practice, quantum cosmologists often solve a functional integral that stands in place of the Wheeler-DeWitt equation. It happens that mathematicians have proven that solutions to a specific path integral, a type of functional integral, correspond to certain solutions to the Wheeler-DeWitt equation. Because it is often easier to solve that specific path integral, quantum cosmologists often, but not always, solve that path integral rather

than the Wheeler-DeWitt equation itself. Not surprisingly, the Wheeler-DeWitt equation can be derived from this path integral. For the mathematically curious, the path integral that quantum cosmologists often use is depicted in Figure 18.2.

16 Hawking, *A Brief History of Time*, 174.

17 Vilenkin, *Many Worlds in One*, 205, emphasis added.

18 "Platonism about mathematics (or *mathematical Platonism*) is the metaphysical view that there are abstract mathematical objects whose existence is independent of us and our language, thought, and practices" (Linnebo, "Platonism in the Philosophy of Mathematics").

19 Gage, "Darwin, Design & Thomas Aquinas."

20 Kline, "Theories, Facts, and Gods"; Meyer, "Of Clues and Causes," 91.

21 As Vilenkin and Yamada state, "The resulting wave function can be interpreted as describing *a universe originating at zero size*, that is, from 'nothing'" ("Tunneling Wave Function of the Universe"; emphasis added).

22 Drees, "Interpretation of 'The Wave Function of the Universe.'"

23 Hawking and Hartle, for example, claim that the "ground state of the wave function" allows them to calculate the probability of the universe coming into existence "from nothing." As mentioned in n. 47 on page 506, in ordinary quantum mechanics, knowing the ground-state wave function allows the physicist to calculate the probability that an electron in its lowest orbital will be found at a specific place. By analogy, in quantum cosmology, the ground-state wave function allows quantum cosmologists to calculate the probability that any given universe with a given geometry will be the one we observe out of the superposition of possible universes described by the wave function. Nevertheless, Hawking and Hartle do not explain what causes the universe to begin from the singularity that they presuppose in their mathematical procedure.

Instead, Hawking and Hartle calculate the ground state by summing possible paths from an initial singularity to different possible geometries and mass-energy configurations (i.e., different possible universes) in a restricted mini-superspace. They claim that "the ground state is the amplitude for the universe to appear from nothing," but what they really mean is that the ground-state wave function allows them to calculate the probability of a specific universe *evolving* from the singularity. Indeed, by their own logic, the ground-state cannot explain a universe appearing out of nothing. Instead, it represents the probability of observing a universe with a given geometry evolving or arising out of a true singularity of zero spatial volume.

24 In the case of quantum tunneling, the tunneling occurs not only after the quantum cosmologists have already presupposed the existence of a universe, but also after they have assumed that universe to be expanding in opposition to a potential energy barrier—one produced by a matter field associated with space that they have also simply presupposed to exist.

25 Of course, those who interpret the universal wave function instrumentally and interpret its description of different possible configurations of matter and spatial geometries as *merely* an abstract mathematical description of different possibilities do not beg the question, since they do not presuppose that these mathematical constructs, or the possibilities they describe, correspond to an *actual* universe. They merely regard these mathematical constructs as describing possible universes with different properties. Nevertheless, the universal wave function then cannot, by the same token, offer a causal explanation for the origin of the universe, because it does not posit an actual material state with causal powers that could conceivably generate a universe. Attempting to conjure a material reality out of a purely mathematical description in this way would, again, commit the fallacy of "reification."

26 Halliwell, "Introductory Lectures on Quantum Cosmology," 38–39.

27 As Vilenkin has noted: "Thus, to explain the initial conditions of the universe, all we need to do is find the wave function ψ from [the Wheeler-DeWitt] eq. (9). However,

as any differential equation, it has an infinite number of solutions" ("Quantum Cosmology," 7).

28 Vilenkin, "Quantum Cosmology," 7.

29 Vilenkin and Yamada, "Tunneling Wave Function of the Universe."

30 As Vilenkin nicely summarizes his procedure: "The role of the Schrödinger equation [in quantum cosmology] is played by the Wheeler-DeWitt equation, which is a functional differential equation on superspace. Since one does not know how to solve such an equation, *one restricts the infinite number of degrees of freedom of* $g_{\mu\nu}$ *and* ϕ [spatial geometries and matter fields] *to a finite number*; the resulting finite-dimensional manifold is called *mini-superspace*. Here we shall employ a simple mini-superspace model in which we restrict the 3-geometry to be homogeneous, isotropic and closed, so that it is described by a single scale factor a" ("Quantum Origin of the Universe," 144).

31 Hartle and Hawking, "Wave Function of the Universe," 2967; emphasis added.

32 In jargon of the discipline, the Hawking-Hartle model utilized a Euclidean rather than a Lorentzian metric. In a Euclidean metric, time is treated like a dimension of space ($ds^2 = dx^2 + dy^2 + dz^2 + c^2dt^2$), whereas a Lorentzian metric distinguishes between the status of spatial and temporal dimensions in its spatiotemporal structure ($ds^2 = dx^2 + dy^2 + dz^2 - c^2dt^2$). For an accessible discussion of oscillating versus nonoscillating regions of superspace in the context of quantum cosmological models, see Isham, "Theories of the Creation of the Universe," esp. 68–81.

33 Hartle and Hawking, "Wave Function of the Universe," 2967.

34 Hartle and Hawking, "Wave Function of the Universe," 2967.

35 James Hartle, "What Is Quantum Cosmology?" *Closer to Truth*, https://www.closerto truth.com/series/what-quantum-cosmology.

36 More precisely, they arbitrarily restricted degrees of mathematical freedom to ensure that the paths through superspace that they summed would produce a "ground-state" wave function that could be used to calculate another "excited-state" wave function that included universes *capable of tunneling into universes* with *geometries* similar to our own. See n. 50 for additional details Chapter 17. See also Gordon, "Balloons on a String," 563–69.

37 Theoretical physicist Jonathan Halliwell makes this same point using more technical terminology. Hawking and Hartle, he writes, "impose initial conditions on the histories [their mathematical path-integral procedure] which ensure that (i) the four-geometry closes, and (ii) the saddle-points of the functional integral *correspond to metrics and matter fields which are regular solutions to the classical field equations* matching the prescribed data on the bounding three-surface B" ("Introductory Lectures on Quantum Cosmology," 41).

38 Hartle and Hawking, "Wave Function of the Universe," 2960, emphasis added.

39 Interestingly, a recently proposed competing theory of quantum gravity known as loop quantum gravity (LQG) is subject to the same problem. For an extensive discussion of loop quantum gravity and why it neither explains nor attempts to explain the origin and the fine tuning of the universe, see Chapter 18, n. a, at www.returnofthegodhypothesis /extendedresearchnotes. See also Baggott, *Quantum Space*, xii–xiii; Rovelli, "Loop Quantum Gravity"; Date and Hossain, "Genericness of Inflation in Isotropic Loop Quantum Cosmology"; Mithani and Vilenkin, "Collapse of Simple Harmonic Universe"; Carroll, "Against Bounces."

40 Isham, "Theories of the Creation of the Universe," 72.

41 Halliwell, "Introductory Lectures on Quantum Cosmology," 46.

42 Halliwell, "Introductory Lectures on Quantum Cosmology," 46, emphasis added. Halliwell made this point in relation to the Hawking-Hartle model, but it applies just as much to Vilenkin's. As Vilenkin acknowledges, he not only needed to impose boundary conditions on the Wheeler-DeWitt equation in order to solve it, he also needed to add an extra boundary term to prevent generating many unstable solutions to the wave function. He needed to choose this term carefully to match the required boundary

conditions that he had already chosen to make the Wheeler-DeWitt equation soluble. These constraints also constitute an external infusion of information into the mathematical procedure by which Vilenkin modeled the origin and development of the universe.

43 See Gordon, "Balloons on a String," 568–69.

44 Dawkins, *The Blind Watchmaker*, 46–49. See the discussion in Ewert et al., "Efficient Per Query Information Extraction from a Hamming Oracle."

45 Vilenkin, "Quantum Cosmology," 7. Emphasis added.

46 For a technical article summarizing the result of this research effort see, Meyer, "Mind Before Matter: The Unexpected Implications of Quantum Cosmology."

Chapter 19: Collapsing Waves and Boltzmann Brains

1 See Chapter 17, n. 40.

2 The models described earlier focused on a single scalar matter field, but additional fields corresponding to ordinary matter and energy can be included as variations in the models (Kiefer, "Emergence of a Classical Universe from Quantum Gravity and Cosmology").

3 For more information on the controversy, see Collins, "The Many Interpretations of Quantum Mechanics." For attempts to explain the collapse of the universal wave function, see Kiefer, "Emergence of a Classical Universe from Quantum Gravity and Cosmology."

4 Craig, "What Place, Then, for a Creator?"

5 Kiefer, "On the Interpretation of Quantum Theory—from Copenhagen to the Present Day." The philosopher Robert Koons, of the University of Texas, has developed a similar view that invokes the chemical and thermodynamic properties of large macroscopic objects, including measuring devices, to account for the collapse of the wave function; see "The Many-Worlds Interpretation of Quantum Mechanics."

6 See also Faye, "Copenhagen Interpretation of Quantum Mechanics." For a discussion of technical problems with the standard Copenhagen view, see Bell, "Against 'Measurement'"; Wallace, "The Quantum Measurement Problem."

7 Quantum cosmologists have eschewed other non-Copenhagen interpretations of quantum cosmology such as the Bohmian (named for the late physicist David Bohm) interpretation and the GRW (named for the physicists Giancarlo Ghirardi, Alberto Rimini, and Tullio Weber) interpretation. Both of these interpretations presuppose preexisting matter upon which the universal wave function ψ acts. Consequently, in neither interpretation does ψ *produce* matter and energy upon its collapse. Consequently, in neither interpretation can ψ be invoked to explain the origin of the material universe. In the Bohmian interpretation, ψ directs or dictates the movements of preexisting particles. In this interpretation, ψ doesn't produce particles; it just moves them around. Similarly, in the GRW interpretation, the wave function describes how preexisting matter spread (in a wavelike structure) across some extended space and then "collapses" in the specific sense of becoming more densely concentrated. Neither of these interpretations of the quantum mechanics have any utility for quantum cosmologists who want to explain the origin of the universe. Since these interpretations treat ψ and the mass-energy of the universe as distinct entities (rather than mass-energy as a manifestation of ψ), they offer no explanation of how matter (or energy) emerged out of ψ.

8 Everett, "The Theory of the Universal Wave Function."

9 For an excellent defense of the principle of sufficient reason, see Pruss, *The Principle of Sufficient Reason*; Koons and Pruss, "Skepticism and the Principle of Sufficient Reason."

10 Vilenkin, *Many Worlds in One*, 205.

11 Moniz, "A Survey of Quantum Cosmology."

12 Tegmark, *The Multiverse Hierarchy*, 99–126, especially 110.

13 Tegmark, "Is 'The Theory of Everything' Merely the Ultimate Ensemble Theory?" 5.
14 The Baylor University philosopher of science Alexander Pruss develops this point in his critique of philosopher David Lewis's modal realism; see *Actuality, Possibility, and Worlds*, 117–19.
15 Recall that inflationary cosmology putatively generates new universes with different initial conditions, but not different laws and constants. Thus, this cosmology would not have the problem of new irregular laws generating unpredictable events. Nevertheless, inflationary cosmology envisions random quantum fluctuations in the inflaton field generating an infinite number of new bubble universes as well as random events within different bubble universes. Thus, we could be in a universe in which virtually anything could occur as the result of such random quantum fluctuations (albeit roughly within the framework of the known physical laws of this universe).
16 Tegmark, "What Scientific Idea Is Ready for Retirement?"
17 For a good overview of the problem of Boltzmann brains, see Carroll, "Why Boltzmann Brains Are Bad." See also Page, "Is Our Universe Likely to Decay Within 20 Billion Years?"; "Return of the Boltzmann Brains"; "Susskind's Challenge to the Hartle-Hawking No-Boundary Proposal and Possible Resolutions"; Bousso and Freivogel, "A Paradox in the Global Description of the Multiverse"; Koberlein, "Can Many-Worlds Theory Rescue Us from Boltzmann Brains?"
18 Carroll, "Why Boltzmann Brains Are Bad."
19 See Linde, "Towards a Gauge Invariant Volume-Weighted Probability Measure for Eternal Inflation"; and Bousso, Freivogel, and Yang, "Boltzmann Babies in the Proper Time Measure."
20 Tegmark's mathematical universe hypothesis does not lend itself to the strategy that proponents of inflationary cosmology tried to use to demonstrate the rarity of Boltzmann brains. Recall that inflationary cosmology proponents attempted to establish that the ratio of Boltzmann brains to natural brains is low in one quadrant of space and then tried to show that the frequency of Boltzmann brains would decrease toward a limit as they extended their analysis to larger and larger parts of that same space. In Tegmark's mathematical universe hypothesis the different universes exemplifying different mathematical structures do not reside in the same physical space or share a common time parameter, so no such extrapolation is possible. In more technical terms, his model rules out any plausible way of "managing" Boltzmann brains by applying a "measure function."
21 Tegmark, "Infinity Is a Beautiful Concept—and It's Ruining Physics." As he says, "Not only do we lack evidence for the infinite but we don't need the infinite to do physics. Our best computer simulations, accurately describing everything from the formation of galaxies to tomorrow's weather to the masses of elementary particles, use only finite computer resources by treating everything as finite. So if we can do without infinity to figure out what happens next, surely nature can, too—in a way that's more deep and elegant than the hacks we use for our computer simulations. Our challenge as physicists is to discover this elegant way and the infinity-free equations describing it—the true laws of physics. To start this search in earnest, we need to question infinity. I'm betting that we also need to let go of it."
22 Tegmark, "Our Mathematical Universe," 101–50.
23 Someone could wonder whether quantum cosmology accurately describes the origin of the universe at all. Quantum cosmology is based upon an *analogy* with ordinary quantum mechanics. But quantum mechanics uses mathematics to describe an actual physical system that already exists. Quantum cosmology attempts to use analogous mathematics to conjure a universe into existence. In ordinary quantum mechanics, the Schrödinger equation and its solution, the wave function, describes an actual physical system: a light source, photons, a barrier with slits, and a detector. But what in quantum cosmology corresponds to the light source? Or the detector? Or the barrier or the screen? Quantum cosmologists would say that the light source and the screen with a detector are analogous

to the boundary conditions that they impose on the Wheeler-DeWitt equation. But they have to impose those boundary conditions *arbitrarily* precisely because *no physical systems yet* exist to which their mathematical descriptions apply.

Consequently, as I argued in the previous chapter, quantum cosmologists have to first presuppose the existence of a universe in order to construct a wave function that allegedly explains its origin. But in ordinary quantum mechanics that would be like calculating the wave functions for a hypothetical photon and experimental apparatus and then expecting the equations to cause the apparatus and the photon to pop into existence. The mathematical apparatus of quantum mechanics describes *something*. The mathematical apparatus of quantum cosmology must *presuppose* something in order for the mathematics to apply to anything. Thus, it may be that the mathematics of quantum cosmology and quantum mechanics are analogous, but the physical situations to which the math is being applied are not. That at least raises a question about whether the math of the one (quantum mechanics) applies to the physics of the other (the universe) in a meaningful way.

Chapter 20: Acts of God or God of the Gaps?

1 Dawkins, *The Blind Watchmaker*, 1, emphasis added.
2 Dawkins, *The Blind Watchmaker*, 7.
3 Knapton, "Stephen Hawking's Final Book."
4 Gould, "Nonoverlapping Magisteria"; *Rocks of Ages*, 14.
5 Galileo and Finocchiaro, *The Essential Galileo*, 119. This is in Galileo's letter to the Grand Duchess Christina (1615). Galileo used this aphorism, but claimed it originated with Cardinal Cesare Baronio.
6 MacKay, *The Clockwork Image*, 51–55; Van Till, *The Fourth Day*, 208–15; Van Till, Young, and Menninga, *Science Held Hostage*, 39–43, 127–68. For a different interpretation of complementarity that affirms methodological autonomy of science and religion, but conjoins their findings, see also Gruenwald, "Science and Religion."
7 Newton, *The Mathematical Principles of Natural Philosophy*, 391–92. The more recent Cohen and Whitman translation passage renders this passage as: "the discussion of God, and to treat of God from phenomena is certainly a part of natural philosophy." Newton, *Mathematical Principles of Natural Philosophy*, 942.
8 For a more nuanced reading of this passage in conjunction with related sayings in some of Newton's unpublished manuscripts, see Snobelen, "Isaac Newton."
9 Not all scholars who have written for the BioLogos website oppose intelligent design. For example, historian of science Ted Davis neither supports nor opposes intelligent design. Even so, the most prominent leaders of BioLogos have strenuously opposed and critiqued intelligent design. See, e.g., Collins, *The Language of God*, 181–96; Falk, "Thoughts on *Darwin's Doubt*, Part 1"; "Further Thoughts on 'Darwin's Doubt' after Reading Bishop's Review"; Haarsma, "Reviewing 'Darwin's Doubt'"; "Response from Evolutionary Creation"; Venema, "Intelligent Design and Nylon-Eating Bacteria"; Venema and Kuebler, "Biological Information and Intelligent Design"; Venema and McKnight, *Adam and the Genome*, 67–92.
10 "Are Gaps in Scientific Knowledge Evidence for God?"
11 Recall that in Newton's time scientists (as we would call them today) were called natural philosophers.
12 Here's another version of this often told story published in a more scholarly volume: "Perhaps the most famous example of the God-of-the-gaps argument came about when Isaac Newton considered the question of the long-term stability of the solar system. He was not able to calculate whether the small gravitational forces between pairs of planets would cancel on the average or accumulate. He considered that in the latter case the unstable behavior would be avoided by the gentle action of God, applying small forces at

the right times and places. A century later, Pierre Simon de Laplace showed that the solar system is indeed stable against such perturbations. When his former student, Napoléon Bonaparte, asked why Laplace's treatise on celestial mechanics did not mention God, Laplace answered, 'I did not need that hypothesis'" (Albright, "God of the Gaps," 955).

13 Shermer, "ID Works in Mysterious Ways."

14 McMullin, "The Virtues of a Good Theory."

15 Robert Larmer has argued that theistic arguments based upon gaps in the natural order do not necessarily commit the fallacy of arguing from ignorance. He argues that it is simply dogmatic to insist that God can never be the cause of an event in nature. Instead, he argues that some *apparent* cases of "arguments from ignorance" have considerable epistemic force. He observes that "presumed examples of the fallacy of *argumentum ad ignorantiam* can often be redescribed in a positive way that makes them seem not to be arguments from ignorance at all" ("Is There Anything Wrong with 'God of the Gaps' Reasoning?", esp. 131).

16 "Are Gaps in Scientific Knowledge Evidence for God?"

17 Recall this argument is based upon our own introspective awareness of our conscious minds. We all intuitively sense that we have the ability to produce abrupt changes of state (free will) uncompelled by material causes. I noted that, though positing the uncaused act of an agent did represent an exception to the rule that "all events have causes," it did not undermine scientific rationality in so doing. On the other hand, positing or allowing the possibility of uncaused *material* events not only violates the principle of sufficient reason; it does so in a way that undermines our confidence in the intelligibility of nature and scientific rationality. See the discussion in Chapter 12.

18 See Hume's *Dialogues Concerning Natural Religion*, Part II: "And will any man tell me with a serious countenance, that an orderly universe must arise from some thought and art like the human, because we have experience of it? To ascertain this reasoning, it were requisite that we had experience of the origin of worlds; and it is not sufficient, surely, that we have seen ships and cities arise from human art and contrivance."

19 Scriven, "Causes, Connections and Conditions in History," 249–50.

20 Critics of the God hypothesis could argue that we have no experience of minds creating matter *ex nihilo*, and further that the power to create matter from nothing is a qualitatively different power than the power to create a new structure by arranging or reconfiguring preexisting matter. Consequently, they could argue that positing a God with the power to generate matter itself *ex nihilo* does not qualify as a reasonable extrapolation from the causal powers of a known entity.

Nevertheless, we do have experience of minds choosing to actualize specific states out of a larger ensemble of possibilities, thereby using and/or generating information. Moreover, since the advent of quantum mechanics, we now understand that a material particle (matter) results from the informative actualization of a possible state from among a much larger ensemble of states described by a quantum wave function. In other words, in quantum mechanics matter results from an informational input as an observation or interaction with a larger macroscopic object results in the actualization of a specific material state from an ensemble of possible states described by a wave function (i.e., the collapse of the wave function). Moreover, we know that intelligent agents have demonstrated the ability to actualize specific states out of a larger ensemble of possibilities, thus using or generating information. Thus, theists could argue that human minds have demonstrated a "relevantly similar" causal power to that required to actualize specific states of affairs described by quantum wave function—that is, they can choose among possibilities, thus using or generating information. Since human choices can actualize possibilities and generate information, it is reasonable to extrapolate and postulate that a divine mind using a relevantly similar but greater causal power could choose among possibilities described by quantum (or universal) wave functions to actualize specific states of affairs resulting in the production of matter or the universe itself.

21 I'm indebted to Paul Nelson for thinking of this illustration. For a thorough critique of the use of the God-of-the-gaps objection to prohibit the use of intelligent causes in explanations of the history of life, see Meyer and Nelson, "Should Theistic Evolution Depend on Methodological Naturalism."

22 Tyson continued at great length in his 2010 lecture to indict Newton for his fallacious reasoning. For Tyson's badly misinformed history of science on display in an extended excerpt from the transcript of his 2010 lecture, see Chapter 20, n. a, at www.returnofthe godhypothesis/extendedresearchnotes. Notice there that Tyson asserts, among many other errors, that Newton thought that the solar system was unstable.

23 Newton, *Mathematical Principles of Natural Philosophy*, 941.

24 Newton, *Mathematical Principles of Natural Philosophy*, 940. In the *Principia*, Newton also developed four methodological principles or "rules of reasoning" in natural philosophy, including a version of the *vera causa* principle. He articulated this principle as follows: "No more causes of natural things should be admitted than are both true and sufficient to explain their phenomena" (794). For a discussion of how Newton applied his *vera causa* principle to justify the God hypothesis without making a God-of-the-gaps argument, see Chapter 20, n. b, at www.returnofthegodhypothesis/extendedresearchnotes.

25 As Newton wrote there: "How came the Bodies of Animals to be contrived with so much Art, and for what ends were their several parts? Was the Eye contrived without Skill in Opticks, and the Ear without Knowledge of Sounds? . . . And these things being rightly dispatch'd, does it not appear from Phænomena that there is a Being incorporeal, living, intelligent, omnipresent?" (*Opticks*, 369–70).

26 Courtenay, "The Dialectic of Omnipotence in the High and Late Middle Ages," 243–69; Kaiser, *Creational Theology and the History of Physical Science*, 53–55.

27 Newton, *Mathematical Principles of Natural Philosophy*, 815–20 (Book III, Propositions X–XV).

28 Newton, *Mathematical Principles of Natural Philosophy*, 816 (Book III, Proposition XI).

29 Newton, *Mathematical Principles of Natural Philosophy*, 816–17 (Book III, Proposition XII).

30 Newton, *Mathematical Principles of Natural Philosophy*, 815–16 (Book III, Proposition X).

31 Newton, *Mathematical Principles of Natural Philosophy*, 940. The passage commonly cited to justify the claim that Newton specifically invoked episodic divine acts to adjust the motions of the planets appears in the General Scholium of the *Principia*. There Newton argues that though the planetary bodies may "persevere in their orbits by the mere laws of gravity, yet they could by no means have at first derived the regular position of the orbits themselves from those laws," and he goes on to argue that "this most beautiful System of Sun, planets and comets could only proceed from the counsel and dominion of an intelligent and powerful being." Science popularizers and historians often misinterpret these passages. [See for example, the BioLogos staff-written article, "Are Gaps in Scientific Knowledge Evidence for God?"] Notice that in the passages from the General Scholium, Newton does not say that God intervenes to *fix* the planetary orbits or to stabilize the system. Instead, he's talking about the *origin* of the solar system and its manifest order and stability. He recognizes that the laws of nature describe regularities, but also that they do not explain the origin of *specific initial conditions* of systems that make those regularities possible.

Thus, later in the General Scholium he amplifies that argument by explaining that "no variation in things arises from blind metaphysical necessity [i.e., the laws of nature], which must be the same always and everywhere." Instead, he argues that "All the diversity of created things, each in its place and time, could only have arisen from the ideas and the will of a necessarily existing being" (942). Newton here displays a sophisticated understanding of what the laws of nature do—and don't do. Specifically, in this case, he realizes that his universal law of gravitation *can* describe the regularities in the planetary motions but can't *in principle* determine the specific and irregular initial conditions of the solar system (or any system) to which the law applies. Yet since the present stability of the system depends upon a highly specific and irregular (or complex) positioning of "the Sun, planets and comets," he infers the activity of a designing intelligence as an explanation for the origin of the system itself. Nevertheless, he does not claim that God, after establishing this system, periodically intervenes to adjust irregularities in the system. Instead, he makes an initial-condition *fine-tuning* argument based on a correct understanding of what agents can do (arrange matter in highly specific and complex ways to accomplish desired ends) and what laws can't.

Moreover, in the BioLogos article cited above, the authors do distinguish between Newton's interest in "the ongoing motion of the planets" and "the origin of the motions." But the authors provide no citations from the *Principia* to show that Newton posited God's singular, episodic action to adjust ongoing planetary motions. They do cite the passage from the General Scholium noted above in which Newton credits God with *the origin* and design of the solar system. Nevertheless, because they give no supporting quotes for their claim that Newton postulated singular divine interventions into the *ongoing* workings of the solar system, the quote attributing the initial design of the solar system to God gives the false impression that Newton also proposed episodic and singular acts of God to fix (alleged) irregularities and perturbations. Indeed, they repeat the same false story as Tyson without any direct attribution. As they put it: "Newton suspected that these gravitational perturbations would accumulate and slowly disrupt the magnificent order of the solar system. To counteract these and other disruptive forces, Newton suggested that God must necessarily intervene occasionally to tune up the solar system and restore the order. Thus, God's periodic *special* actions were needed to account for the ongoing stability of the solar system [emphasis added]."

32 Stephen Snobelen, an excellent Newton scholar at the University of King's College in Halifax, Nova Scotia, also rejects the claim that Newton made God-of-the-gaps arguments. He emphasizes that because Newton thought God continuously upheld the laws of nature, he did not think that nature could have gaps in its lawlike regularities in need of filling. As he put it, "The 'God of the gaps' critique applied to Newton can imply that where God isn't filling a gap, He is not at work. But Newton believed that God is ultimately behind all operations in the cosmos." Indeed, Newton saw God constantly sustaining the orderly concourse of the universe through what we call the laws of nature. Those laws admit no gaps for God to fill with special divine interventions, since in Newton's view God sustains the orderly concourse of nature on a moment by moment basis. Moreover, since God's predictable action and character are precisely what allow us to perceive the existence of laws of nature at all, Newton's affirmation of constant divine action in sustaining the order of nature did not inhibit his scientific investigation of it. Just the opposite. His view of God's dominion over nature inspired it—a point that Snobelen has emphasized to me in correspondence.

In addition, Snobelen notes the passages often cited as evidence of Newton's invoking God to fill gaps are instead "expostulations of natural theology," that is, design arguments celebrating the wisdom of God in establishing the natural order in the first place ("Newton and the God of the Gaps"). For example, Newton also made design arguments that implied that God had acted in the past to design the integrated complexity of the eye and establish the specific material conditions that made the stability of the solar system possible. Yet Newton's invoking of divine action in this way does not constitute a GOTG fallacy for the same reason that contemporary intelligent design arguments do not constitute instances of a fallacy as explained in this chapter. Newton inferred intelligent design based upon the presence of features in nature that—given *our knowledge* of cause and effect—are best explained by the activity of an intelligent cause.

Even so, Snobelen allows how one passage in the Newton corpus might provide some support for the idea that Newton *envisioned* the need for divine action to fix the solar system at some point far into the future (as opposed to invoking God's intervention at episodic intervals on an ongoing basis, as most versions of the God-of-the-gaps story assert). Snobelen notes that in a short passage in Query 31 in the *Opticks*, Newton anticipates that "some inconsiderable Irregularities" will arise "from the mutual Actions of Comets and Planets upon one another." And that those irregularities "will be apt to increase, *till this System wants a Reformation*" (emphasis added). Even so, Snobelen views this passage neither as evidence of Newton's willingness to invoke divine action to fix irregularities in the ordinary concourse of nature nor of his having a penchant for invoking such action to the exclusion of looking for lawful regularities in nature. Instead, Snobelen argues that Newton, as a student of biblical eschatology, anticipated that the solar system, like nature itself, would one day run down, after which God would remake the heavens and the earth. As Snobelen explains: "The trajectory toward decline has its remedy in the God of dominion, who reforms and adjusts to keep the cosmos orderly, and who recreates when the time comes for a new heaven and a new earth. Newton's cosmos is not deterministic in the secular and materialistic senses often applied to him; nevertheless, its future is ultimately guided by divine action." See Snobelen, "Cosmos and Apocalypse," esp. 93.

In my view, reading Query 31 in the *Opticks* in context casts further doubt on the claim that Newton made a God-of-the-gaps argument there. First, in the following sections of this passage, Newton *does not postulate any specific act of God* or angels to rectify these anticipated irregularities. Instead, he seems only to be affirming the reality of what physicists today would call entropy, the tendency of systems to move from order to disorder over time. (Snobelen has told me in personal correspondence that he interprets this passage in much the same way, as Newton affirming a kind of proto-entropy concept.) Second, in Book III of the *Principia*, Newton shows mathematically that the solar system is stable over "a long tract of time" and consequently shows no concern whatsoever in that most relevant section of his corpus to posit direct divine action to remedy orbital irregularities or instabilities in the solar system.

Third, in Query 31 Newton is marveling at the "wonderful Uniformity in the Planetary System" and arguing that the order of the system arose "in the first Creation by the Counsel of an intelligent Agent." Thus, he does invoke divine action, but, again, only as the cause of the "Origin of the World." He does not postulate any specific divine action to stabilize the solar system, on an ongoing basis or even at some time in the future. Here's the passage in question:

> "Now by the help of these Principles, all material Things seem to have been composed of the hard and solid Particles above mention'd, variously associated in the first Creation by the Counsel of an intelligent Agent. For it became him who created them to set them in order. And if he did so, it's unphilosophical to seek for any other Origin of the World, or to pretend that it might arise out of a Chaos by the mere Laws of Nature; though being once form'd, it may continue by those Laws for many Ages. For while Comets move in very excentrick Orbs in all manner of Positions, blind Fate could never make all the Planets move one and the same way in Orbs concentrick, some inconsiderable Irregularities excepted which may have risen from the mutual Actions of Comets and Planets upon one another, and which will be apt to increase, till this System wants a Reformation. Such a wonderful Uniformity in the Planetary System *must be allowed the Effect of Choice*. And so must the Uniformity in the Bodies of Animals." (*Opticks*, 402)

33 See especially Book III of the *Principia*, where Newton specifically analyzes the perturbations in planetary orbits.

34 Snobelen points out that Newton had a providential and dynamic view of the cosmos that paralleled his interpretation of biblical eschatology. For an extensive discussion of what that implied for Newton's view of divine action in the natural world and why it did not imply that he made God-of-the-gaps arguments, see Chapter 20, n. c, at www .returnofthegodhypothesis/extendedresearchnotes.

35 Snobelen, "Newton and the God of the Gaps"; see also 'God of Gods and Lord of Lords.'
36 See also Iliffe, *Priest of Nature*.
37 The first reflecting telescope was invented by James Gregory.

Chapter 21: The Big Questions and Why They Matter

1 Hawking, *Brief Answers to the Big Questions*, 23–38.
2 Hawking and Mlodinow, *The Grand Design*, 180.
3 By invoking spontaneous creation, Hawking was drawing an analogy to a physical process known as virtual particle production (or spontaneous particle/antiparticle production). In this process, described by the Heisenberg uncertainty principle, a particle can emerge spontaneously out of an energy-rich quantum field for a time provided an antiparticle with equivalent negative energy also arises. If the net energy of this process cancels out to equal zero total energy, it does not violate the law of the conservation of energy. Nevertheless, the mathematical equation that describes how this can occur describes an actual—that is, already existing—physical situation in which particles (and their virtual complements) arise out of a preexisting energy-rich space. The particle/antiparticle production is made possible by the prior existence of the energy-rich quantum field and occurs in a preexisting space. Thus, the analogy that Hawking draws is not apt. The laws of physics that describe this process do not apply to the origin of the universe itself, because before the universe existed there was no space or energy to draw on to drive the particle (universe) production.
4 Hawking and Mlodinow, *The Grand Design*, 180.
5 Hawking, *Brief Answers to the Big Questions*, 29.
6 Hawking, *Brief Answers to the Big Questions*, 38.
7 Hawking, *Brief Answers to the Big Questions*, 33.
8 Hawking, *Brief Answers to the Big Questions*, 38.
9 Dawkins, *River Out of Eden*, 17; see also 12, 18–20.
10 Dawkins, *River Out of Eden*, 133.
11 Weinberg, *The First Three Minutes*, 154.
12 David Masci, "Public Opinion on Religion and Science in the United States," *Pew Research Center*, November 9, 2005, http://www.pewforum.org/2009/11/05/public-opinion-on-religion-and-science-in-the-united-states.
13 The Pew poll also notes that, although the majority of Americans believe science and religion often conflict *in general*, the majority also regard science as not conflicting with their *particular* religious beliefs: "A solid majority of Americans (61%) say that science does not conflict with *their own* religious beliefs" (emphasis added).
14 West, *Darwin's Corrosive Idea*, 3–7.
15 The quote I encountered actually came from the Christian philosopher Francis Schaeffer, who appears to have paraphrased and synthesized some of Jean-Paul Sartre's key ideas (see Schaeffer, *He Is There and He Is Not Silent*, 1). Here's a passage from Sartre that expresses some of the ideas that Schaeffer may have been summarizing: "The existentialist, on the contrary, finds it extremely embarrassing that God does not exist, for there disappears with Him all possibility of finding values in an intelligible heaven. There can no longer be any good *a priori*, since there is no infinite and perfect consciousness to think it. It is nowhere written that 'the good' exists, that one must be honest or must not lie, since we are now upon the plane where there are only men. Dostoievsky [*sic*] once wrote 'If God did not exist, everything would be permitted'; and that, for existentialism, is the starting point. Everything is indeed permitted if God does not exist, and man is in consequence forlorn" (Sartre, "Existentialism and Humanism," 70–71; see also 65–76). In his novel *Nausea* (1938),

Sartre expresses the idea that the death of God has specifically left humankind without ultimate meaning.

16 Russell, *Mysticism and Logic and Other Essays*, 10–11.

17 Lewis, *Miracles: A Preliminary Study*, 102; see also 100–107.

18 Other thinkers have articulated arguments of a similar ilk as well. See, e.g., Menuge, *Agents Under Fire*; Willard, "Knowledge and Naturalism," 24–48; Lewis, *Miracles*; Reppert, *C. S. Lewis's Dangerous Idea*; Crisp, "On Naturalistic Metaphysics," 61–74.

19 More precisely, as Plantinga says elsewhere, "A belief has warrant for a person *S* only if that belief is produced in *S* by cognitive faculties functioning properly (subject to no dysfunction) in a cognitive environment that is appropriate for *S*'s kind of cognitive faculties, according to a design plan that is successfully aimed at truth" (*Warranted Christian Belief*, 156).

20 For a short summary of how Plantinga summarizes his own argument, see Chapter 21, n. a, at www.returnofthegodhypothesis/extendedresearchnotes. See also, Plantinga, *Where the Conflict Really Lies*, 314, emphasis in original.

21 Plantinga, "Evolution vs. Naturalism."

22 Koons, "The General Argument from Intuition." For related arguments, see also "Epistemological Objections to Materialism" and "The Incompatibility of Naturalism and Scientific Realism."

23 Darwin Correspondence Project, "Letter no. 13230." See also Darwin, *The Autobiography of Charles Darwin 1809–1882*, 92–93.

24 Plantinga, *Warrant and Proper Function*, 225.

25 Plantinga, *Warrant and Proper Function*, 225.

26 Dawkins, Interview with Ben Wattenberg.

27 In his more recent book *The God Delusion*, Dawkins accounts for the origin of religion in terms of "memetic natural selection" rather than "genetic natural selection." In this way, he attempts to distance natural selection from the production of cognitive equipment that enabled the origin, development, and promulgation of (false) religious beliefs. Yet in Dawkins's view, "genetic natural selection" undergirds the origin of all human cognitive faculties (indeed, of *all* of flora and fauna on earth), including human brains capable of forming and passing along "memes." This leaves his account of the origin of our cognitive equipment *ultimately* resting on natural selection, in combination with other evolutionary processes, as the fundamental force that enabled the development and spread of what he regards as a false belief (*The God Delusion*, chap. 5).

28 Barrett, *Born Believers*. For more extensive documentation of these claims, see Chapter 21, n. a, at www.returnofthegodhypothesis/extendedresearchnotes.

29 Gopnik, "See Jane Evolve." For more extensive documentation of these claims, see Chapter 21, n. a, at www.returnofthegodhypothesis/extendedresearchnotes.

30 See Pew Research Center, "The Changing Global Religious Landscape," "The Future of World Religions: Population Growth Projections, 2010–2050." And as Conrad Hackett and colleagues note in other research: "The religiously unaffiliated are projected to decline as a share of the world's population in the decades ahead because their net growth through religious switching will be more than offset by higher childbearing among the younger affiliated population" (Hackett et al., "The Future Size of Religiously Affiliated and Unaffiliated Populations," 829–42 [830]).

31 Plantinga argues that to justify the reliability of the mind, evolutionary naturalism requires that adaptive beliefs need to correlate with truth. As noted, he provides many reasons to doubt that coupling. Yet he also argues that other ways of conceiving of the relationship between belief and adaptive behavior also reinforce doubts about the reliability of the mind. Indeed, he notes that there are several different mutually exhaustive ways of conceiving of the relationship between the mind and body—and thus between cognitive states and behaviors—given philosophical naturalism. For each

such way of conceiving of this relationship, he argues that the probability of the reliability of our belief-forming apparatus (and consequent beliefs) is either inscrutable or low.

For example, evolutionary naturalists might hold to (a) various epiphenomenalist views of mind-body interaction. Epiphenomenalism denies that either our beliefs or the specific semantic content of those beliefs affect our behaviors. It follows in this view that our beliefs would be invisible to natural selection and the probability of our possessing reliable beliefs given naturalism and evolution—that is, P(R | N + E)—would be low or inscrutable. Indeed, in this case, the action of natural selection would certainly not give us a reason to trust (or certify) the reliability for the mind.

Naturalists might also hold the view that beliefs *do* cause behaviors, but they are either (b) maladaptive and true or (c) adaptive and false. For both these cases he argues that the probability of possessing reliable beliefs given evolutionary naturalism, P(R | N + E), is again very low. In the case of (b), where beliefs are true but maladaptive, natural selection would weed out cognitive structures that produce such beliefs. In the case of (c), where beliefs are false but adaptive, natural selection would preserve cognitive structures responsible for producing false beliefs, again, casting doubt on the reliability of our cognitive equipment. Since Plantinga also offers many reasons for doubting that adaptive beliefs will necessarily be true, he concludes that there are good reasons to doubt the reliability of our belief-forming structures—given any conceivable conjunction of evolution and a naturalistic view of the relationship between belief and behavior or mind and body.

32 Plantinga uses this phrase in a number of texts, including, for example, *Warranted Christian Belief*, 231.

33 Plantinga's refinements to his original argument along with critics' objections and his replies can be found in the following: Plantinga, *Warranted Christian Belief*, 227–40, 281–84, 350–51; Beilby, ed., *Naturalism Defeated?*; Law, "Naturalism, Evolution, and True Belief," 41–48; Fitelson and Sober, "Plantinga's Probability Arguments Against Evolutionary Naturalism," 115–29; Plantinga, "Reliabilism, Analysis and Defeators"; "Probability and Defeators"; Plantinga and Tooley, *Knowledge of God*, 31–51, 227–32; Plantinga, "Content and Natural Selection"; *Where the Conflict Really Lies*, 307–50.

34 Plantinga, "Evolution vs. Naturalism"; see also *Warrant and Proper Function*, 236–37.

35 Plantinga, "Evolution vs. Naturalism," emphasis in original.

36 In *Where the Conflict Really Lies*, Plantinga takes his argument one step farther: he applies this line of thinking, along with other considerations, to the question, "Is theism or naturalism more compatible with science?" (265–350). He contends that, if evolution is true, then naturalists have a major problem: the conjunction of naturalism and evolution undermines the reliability of naturalists' cognitive faculties (as we have already noted). By contrast, the Judeo-Christian doctrine of the *imago dei* and other conceptual and metaphysical resources of Judeo-Christian theism provide a suitable (epistemological) ground for the pursuit of scientific knowledge. Thus, Plantinga concludes, "On balance, theism is vastly more hospitable to science than naturalism" (309).

37 Nagel, *Mind & Cosmos*.

38 According to John Calvin, the *sensus divinitatis* is a natural, inborn "conviction" in all human beings "that there is some God" (McNeill, *Institutes of the Christian Religion*, bk. 1, ch. 3, 46). For a contemporary development of this doctrine, see Plantinga, *Warranted Christian Belief*.

39 Nagel, *The Last Word*, 130–31.

40 Krauss, *A Universe from Nothing*, xii.

41 "Lawrence Krauss: Atheism and the Spirit of Science." Or, as Richard Dawkins says bluntly in the Afterword to Krauss's *A Universe from Nothing*: "Reality doesn't owe us comfort" (188).

42 This line is in the third stanza of Voltaire's poetic reply to the book *The Three*

Impostors. See Voltaire, "Epître à l' auteur du livre des *Trois imposteurs*," 10: 402–5. The text can also be found in French and in English at https://www.whitman.edu/VSA/trois.imposteurs.html.

43 Krauss, "Our Godless Universe Is Precious."

44 Krauss, "Our Godless Universe Is Precious."

45 Krauss, "The Universe Doesn't Give a Damn about Us."

46 Sartre, "Existentialism and Humanism," 69; see also 70–76. In this particular version, the translator uses "abandonment" rather than "forlornness," but the essential concept remains the same.

47 Sartre, "Existentialism and Humanism," 69–76.

48 Frankl, *Man's Search for Meaning*.

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