Return of the God Hypothesis
Extended Research Notes
(Some endnotes in the published version of the book direct readers to these extended notes for more information about select topics)

Chapter 1

Note 1a:

The late Oxford physicist and historian of science P. E. Hodgson observed that many civilizations have had sophisticated material cultures, or what he called "the material requirements for the growth of science." As Hodgson explained: "If we think about what is needed for the viable birth of science, we see first of all that it needs a fairly well-developed society, so that some of its members can spend most of their time just thinking about the world, without the constant preoccupation of finding the next meal. It needs some simple technology, so that the apparatus required for experiments can be constructed. There must also be a system of writing, so that the results can be recorded and sent to other scientists, and a mathematical notation for the numerical results of measurements. These may be called the material necessities of science." As Hodgson put it elsewhere in a longer version of the same article: "If we look at the great civilizations of the past, in China and India, in Babylon and Egypt, in Greece and Rome, we frequently find well-developed social structures, magnificent artistic and architectural achievements, imperishable drama and philosophy, but nothing remotely equivalent to modern science. We find great skill in the working of wood and metal, ingenious mechanical contrivances, and perceptive philosophical speculations about the world, but not the detailed quantitative understanding of matter, from quarks to galaxies, expressed as the solution of a few differential equations, that is the hallmark of the more developed areas of modern science. Most of the great civilizations of the past were able to provide all the material requirements for the growth of science. There was a leisured class, technical skills, and systems of writing and mathematics. Obviously, this by itself is not enough. What was lacking was the attitude of mind toward the material world that is the essential precondition of science, and in some cases a social structure, that allows new ideas to flourish." Hodgson, "The Christian Origin of Science," *Occasional Papers*, 1.

Note 1b.

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. In personal correspondence he writes: "What you say about 'logical necessity' and Aristotle is largely the result of the Christian understanding of Muslim interpretations of Aristotle. Islam, as the mediating point between the Greeks and the twelfth- and thirteenth-century Christians, is really what matters here. There was a debate within Islam about whether God as a perfect being was stuck with the laws of nature he created, so that he couldn't change them without subverting his own perfection. Averroës drew just such a conclusion, and he was the main conduit by which Christians understood Aristotle. His followers ended up pushing science as a self-contained, nontheological ('naturalistic') enterprise. It was these ideas that Tempier condemned in 1277." Thus, Fuller questions the common portrayal of Greek science itself (as opposed to its later interpretation) as hyperrational. Nevertheless, he also emphasizes—as I note in this chapter—the importance of the biblical idea of the fall of man and the fallibility of human reason to the development of rigorous methods of scientific hypothesis testing. In his view, an emphasis on the fallibility of human reason came into greater currency during the Reformation and provided a corrective to the Islamic *interpretation* of Greek science that many medieval Christians had adopted, not necessarily a corrective to Greek science itself. I hold that Greek science, especially as shaped by Aristotle, did entail a more deductive, less empirical approach to the investigation of nature than arose during the Scientific Revolution, but also commend Steve's view to my readers for careful consideration. His view may well provide a corrective to a common historical portrayal of Greek science. Either way, he and I both agree about how Christian ideas about (1) the intelligibility of nature and (2) the rationality *and* fallibility of the human mind inspired what we call modern science.

Note 1c.

After the rediscovery of Aristotle's works in the West in the eleventh century, Christian theologians were eager to synthesize their theological beliefs with the best of classical learning. They often adopted Greek assumptions about what nature must look like. Invoking considerations of logical necessity—and often Aristotle's authority—some medieval theologians and philosophers asserted that the universe must be eternal; that God could not create new species; that God could not have made more than one planetary system; that He could not make an empty space, that He could not give planets noncircular orbits, and many other such propositions. As A.C. Crombie has noted, in Aristotle's cosmos, "each kind of body or substance in this universe had a place that was natural to it and a natural motion in relation to that place. Movement took place with reference to a fixed point, the centre of the earth as the centre of the universe.… The natural behavior of bodies depended, therefore, on their actual place within the universe as well as on the substance of which they were composed" (Crombie, *The History of Science from Augustine to Galileo*, 1:90). As Aristotle believed that there was a defined center of the universe, it follows that there was nowhere else additional planetary systems could be, for there was only one center of the universe. Given that medieval thinkers such as Averroës, Albertus Magnus, and Thomas Aquinas held an Aristotelian view of the natural movements of substances, they would also have believed in the impossibility of multiple planetary systems. Bonaventura and Roger Bacon held alternative theories about how substances moved to their natural places, but with the same conclusions. (Crombie, *The History of Science from Augustine to Galileo*, 2:57.)

Note 1d.
Robert Boyle, one of the most important figures of the scientific revolution and the founder of modern chemistry, explained that the job of the natural philosopher was not to ask what God must have done, but what God actually did. As Boyle wrote, if God is "the author of things, it is rational to conceive, that he may have made them commensurate, rather to his own designs in them, than to the notions we men may best be able to frame of them." Indeed, according to Genesis, "the world itself was first made before the contemplator of it, man: whence we may learn, that the author of nature consulted not, in the production of things, with human capacities; but first made things in such manner, as he was pleased to think fit, and afterwards left human understandings to speculate as well as they could upon those corporeal, as well as other things." (*Christian Virtuoso, I, Appendix*, in Hunter and Davis, eds., *Works*, 12: 374, 397–98). In other words, since human beings weren't around when God made the world, we can't presume that God must have made it in a way that seems rational to us. Therefore, to discern the design of the world, we must observe it. See also: Ted Davis, "The Faith of a Great Scientist: Robert Boyle's Religious Life, Attitudes, and Vocation."

Note 1e.
Robert Boyle argued that God's absolute freedom required an empirical and observational approach, not just a deductive one. As Boyle explained: "The Primordial system of the universe, or the great and original fabric of the world; was as to us arbitrarily established by God. Not that he created things without accompanying, and as it were regulating, his omnipotence, by his boundless wisdom; and consequently did nothing without weighty reasons: but because those reasons are a priori undiscoverable by us: such as are the number of the fixed stars, the colocation as well as number of the planetary globes, the lines and period of their motion,... the bigness, shapes, and differing longevities of Living creatures; and many other particulars: of which the only Reason we can assign, is that it pleased God at the beginning of things, to give the world and its parts also that disposition. (This may be also applied to the states of bodies and the rules of motion.)" (Royal Society, Miscellaneous MS 185, fol. 29)

Note 1f.
As Peter Hodgson observed: "According to Judeo-Christian beliefs the world is the free creation of God from nothing. The structure of the world cannot therefore be deduced from first principles; we have to look at it, to make observations and experiments to find out how God made it. This reinforces the Aristotelian principle that all knowledge comes through the senses, but requires that it be situated within a wider set of beliefs concerning the nature of the world that is implicit in the doctrine of creation" ("The Christian Origin of Science," *Logos*, 145). Hodgson notes that early scientists assumed that the world was both rational—because it was created by a mind—and contingent—because that Mind had acted freely. These assumptions led to "a fresh style of scientific thinking," one that "was made possible by the Judeo-Christian vision of the world" (142).

Chapter 2

Note 2a.

Historian and philosopher of science Steve Fuller makes an interesting observation in correspondence with me about the book of nature metaphor. He notes, "This metaphor [the book of nature] is interesting because I think it came to mean something a bit different from the time of Basil to the Scientific Revolution. The Bible itself was a combination of works from different authors, which suggests by analogy that Nature is a patchwork—which is basically what Aristotle thought. However, the Reformation took much more seriously the idea that the entire Bible is inspired by God even if penned by different authors. This corresponded to the idea of a single designer and a single set of laws [governing all of nature]."

Note 2b.

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 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. It does not understand the languages in which they are written. The child notes a definite plan in the arrangement of the books, a mysterious order, which it does not comprehend, but only dimly suspects. That, it seems to me, is the attitude of the human mind, even the greatest and most cultured, toward God. We see a universe marvelously arranged, obeying certain laws, but we understand the laws only dimly. Our limited minds cannot grasp the mysterious force that sways the constellations" (quoted in Viereck, *Glimpses of the Great*, 372–73).

Note 2c.

Many, including Boyle, referred to themselves as mechanical philosophers and, in so doing, explicitly broke with the Aristotelian scholastic practice of explaining natural phenomena by reference to insensible and, in Boyle's view, unintelligible substantial forms (or formal causes or "virtues.") Boyle and other mechanical philosophers rejected the "naming game" described in the previous chapter and instead insisted on looking for specific physical mechanisms—material interactions between corpuscles of matter or material structures—as explanations for the regularities of nature. For example, Descartes opposed the Scholastic recourse to qualities, writing: "If you find it strange that I make no use of the qualities one calls heat, cold, moistness, and dryness …, as the philosophers [of the schools] do, I tell you that these qualities appear to me to be in need of explanation, and if I am not mistaken, not only these four qualities, but also all the others, and even all of the forms of inanimate bodies can be explained without having to assume anything else for this in their matter but motion, size, shape, and the arrangement of their parts" (*The World*", cited in Slowik, "Descartes' Physics.") Newton also rejected the scholastic practice of explaining phenomena by reference to substantial forms. In his *Opticks*, he writes: "The *Aristotelians* gave the Name of occult Qualities not to manifest Qualities, but to such Qualities only as they supposed to lie hid in Bodies, and to be the unknown Causes of manifest effects.… Such occult Qualities put a stop to the Improvement of natural Philosophy, and therefore of late Years have been rejected. 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).

Note 2d.

Although Zilsel argues that the most prominent Greek philosophers didn't use the term "laws of nature" to describe natural phenomena he acknowledges that: "To classical antiquity also the idea is not quite foreign that physical processes are superintended and enforced by God or gods as by judges" ("The Genesis of the Concept of Physical Law," 249), and later: "At any rate the law-metaphor was not quite unknown to the ancients. This is illustrated by the term 'astronomy.' The Greek word *nomos* means law, and the science of the stars could not have been called astronomy if the idea had not existed that the order and regularity of the stellar movements were analogous to human law" (252). But he goes on to stress the dissimilarity between Greek concepts of regularities as rational principles and the ideas of a law of nature conceived as juridical metaphor for a pattern of order imposed on nature by a governing omnipresent God. The latter concept, he argues, is the source of the idea of the laws of nature used by modern scientists today (253).

Note 2e.

Zilsel notes: "The law-metaphor plays a certain part in the Stoics only. The Stoics were determinists and believed in fate and divine providence. Living in a period of rising monarchies, they viewed the universe as a great empire, ruled by the divine Logos. Consequently, the idea of a natural law was not unknown to them. For the most part it referred to moral prescriptions based on reason. This Stoic idea is the source of the juridical concept of natural law, which influenced jurisprudence and political philosophy through two thousand years. A few times, however, although the two meanings were never neatly separated, the idea was applied by the Stoics to physical processes too. Zeno, the founder of the school, speaks of natural laws in this ambiguous way." In any case, Zilsel argues that generally, "The Stoics were not much interested in physical phenomena and never gave instances of natural law in its physical meaning" (Zilsel, "The Genesis of the Concept of Physical Law," 251).

Note 2f.

Zilsel acknowledges that one early Greek scientist—Archimedes—did describe certain phenomena in terms that we would today regard as laws of nature, in particular his buoyancy principle and what we now call his "law of the lever" and "law of optical reflection." He notes, however, that Archimedes, did not call these principles "laws," but instead principles. Moreover, even though he discovered these principles by observation, he presented them as if they were deductions from self-evident logical postulates or axioms, as Euclid did in his works on geometry. As Zilsel argues: "On the whole one must take good care not to overestimate the similarity of the classical concept of nature and modern natural science. Deterministic ideas were known to the ancients. They were indicated as early as in Heraclitus' doctrine of the fiery Logos, who rules the universe and expresses himself in the cyclic change of matter. They were explained in detail in the Stoic doctrine of fate. Nevertheless, two points must not be overlooked. First, ancient determinists spoke much more frequently of the *logos* than of the *nomos,* more frequently of the *reason* than of the *law* of the universe. Secondly, the classical determinist doctrine had a tinge of myth and emotion rather than of science and experience. Heraclitus and the Stoics felt the development of the whole universe as necessary and enforced, but were not interested in single physical laws" ("The Genesis of the Concept of Physical Law," 254).

Note 2g.
Leibniz suspected that Newton secretly might be attributing the motion of the planets and other gravitating objects to the direct governance of God. Leibniz thought invoking the constant intervention of God in this way impugned God's wisdom by implying that God had not made the machine of the universe properly at the beginning. As Leibniz asserted: "Sir Isaac Newton and his followers have … a very odd opinion concerning the work of God. According to their doctrine, God Almighty wants to wind up his watch from time to time: otherwise it would cease to move" ("*Die Philosophischen Schriften von Gottfried Wilhelm Leibniz*, 352, cited in Brown, "Is the Logic in London Different from the Logic in Hanover?" 145). Leibniz also writes: "If God is oblig'd to mend the course of nature from time to time, it must be done either supernaturally or naturally. If it be done supernaturally, we must have recourse to miracles, in order to explain natural things: which is reducing an hypothesis *ad absurdum*: for every thing may easily be accounted for by miracles. But if it be done naturally, then God will not be intelligentia supramundane: he will be comprehended under the nature of things; that is, he will be the soul of the world" (*Die Philosophischen Schriften*, ""358).

Chapter 3

Note 3a.
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). These versions of the argument were not predicated upon a finite universe. Though they remained in philosophical currency well after the repudiation of the Kalām argument during the Enlightenment, they had less popular appeal due in part to their philosophical complexity, though recent rigorous formulations of these arguments have again gained considerable currency; See, for example: Alexander Pruss, (2006). *The Principle of Sufficient Reason: A Reassessment* (Cambridge Studies in Philosophy). Cambridge: Cambridge University Press]; Alexander R. Pruss (2004). A restricted Principle of Sufficient Reason and the cosmological argument. *Religious Studies*, 40, pp 165-179]. In any case, the assumption of an infinite or eternally self-existing universe seemed to support scientific materialism and, consequently, during the late 19th century had a significant negative affect on both popular and scholarly perceptions of the relationship between science and religion—perhaps in part because Newtonian physics also seemed to support it. By contrast, the resuscitation of the Kalām argument as the result of scientific discovery of the beginning of the

universe in the twentieth century (see Chapters 5 and 6) has provided considerable epistemic support for a theistic worldview, whatever the status of the Thomistic and Leibnizian versions of the cosmological argument then and now.

Note 3b.

The philosophers and scientists sympathetic to the design argument during the nineteenth century had different perspectives about the extent to which the evidence in nature itself compelled its conclusion. William Paley believed that evidence of design was located in nature itself and could be discovered by scientific observation. But others, such as Thomas Reid, thought of the perception of design as a psychological necessity that God had hardwired into human beings, albeit to confirm his existence. Kant for his part thought that the human mind could not help but perceive design in nature, though he was ambivalent about whether that perception of design was accurate.

Note 3c.

There Kaiser argues that the first published report of the conversation between Napoleon and Laplace did not appear until 1864. Nevertheless, he notes that, "the incident corresponds … well with what we do know of the encounters between Laplace and Bonaparte.… It captures the haughtiness and determination of the great mathematician in a single phrase: Newton's God had been retired as far as physical science was concerned." For a possibly earlier report, see also: Antommarchi, *Mémoires du docteur F. Antommarchi, ou les derniers momens de Napoléon*, 282. As William Herschel, who participated in the conversation, reported: "The first Consul then asked a few questions relating to Astronomy and the construction of the heavens to which I made such answers as seemed to give him great satisfaction. He also addressed himself to Mr Laplace on the same subject, and held a considerable argument with him in which he differed from that eminent mathematician. The difference was occasioned by an exclamation of the first Consul, who asked in a tone of exclamation or admiration (when we were speaking of the extent of the sidereal heavens): 'And who is the author of all this!' Mons. De la Place wished to shew that a chain of natural causes would account for the construction and preservation of the wonderful system. This the first Consul rather opposed. Much may be said on the subject; by joining the arguments of both we shall be led to 'Nature and nature's God'" (William Herschel's diary of his trip to Paris, as quoted in Constance A. Lubbock, *The Herschel Chronicle* [Cambridge: Cambridge Univ. Press, 2013], 310).

Note 3d.

The prohibition against invoking creative intelligence, or at least a detectable form of it, arose even before the publication of *Origin of Species*. Natural theologians such as Robert Chambers and Asa Gray, writing just prior to Darwin, tacitly advanced this convention by locating design in undetectable workings of natural law rather than in the complex structure or function of particular objects. [Gillespie, *Charles Darwin and the Problem of Creation*, 38.] This gradually emptied the natural theological tradition of any distinctive empirical content, leaving it vulnerable to charges of being subjective, superfluous, and even vacuous. By locating design more in natural law and less in complex contrivances that could be understood by direct analogy to human creativity, later British natural theologians ultimately made their research program indistinguishable from the fully naturalistic science of the Darwinians. [Dembski, "Demise of British Natural Theology."] As a result, the notion of design, to the extent it maintained any intellectual currency, soon became relegated to a matter of subjective belief. By the end of the nineteenth century, natural theologians could no longer point to any specific artifact or feature of nature that required intelligence as a necessary explanation. Intelligent design became undetectable except "through the eyes of faith."

Chapter 4

Note 4a.

Bonaventure's argument for a finite universe was more subtle and predicated upon a theological premise commonly held by medieval theologians, namely, "that the world depends entirely for its being on God." The *Stanford Encyclopedia of Philosophy* summarizes Bonaventure's argument for a temporal beginning of the universe as follows: "Everything that depends entirely for its being on something else is produced by that thing from nothing. The world depends entirely for its being on God. Hence, the world must be produced from nothing. If the world is produced from nothing, it must either arise out of the '"nothing"' as out of matter or out of the '"nothing"' as out of a point of origin. The world cannot arise out of nothing as out of matter. Thus, the world must arise out of nothing as out of a point of origin. If, however, the world arises out of nothing as out of a point of origin, then the world has being after non-being. Nothing having being after non-being can be eternal. The world, as a created thing, has being after non-being. Therefore, the world, precisely as created '"out of nothing,"' cannot be eternal. The philosophical force of the expression that there be a logical moment at which we could say that the world is not and with reference to which the world begins to be. The ontological reference of such a logical moment is the divine eternity with respect to which ('after' which) the world begins" (Tim Noone and R. E. Houser, "Saint Bonaventure").

Note 4b.

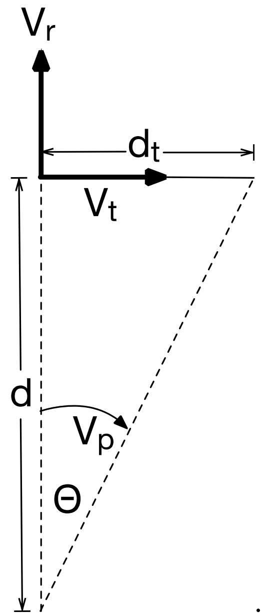
Poe likely knew by this time that the speed of light was finite. Aristotle had long before argued that the speed of light was infinite, which would not have resolved Olbers's paradox. But in 1676, almost two centuries before Poe wrote, the Danish astronomer Ole Rømer (1644–1710) observed that the measured orbital period of a moon of Jupiter was shorter when the earth was approaching Jupiter than when it was receding from it. From these measurements he determined that the speed of light was finite. However, he could not calculate an actual value, since he did not know the distance between the earth and the sun. In 1678 Christian Huygens estimated the distance to the sun. This allowed him to the make the first rough estimate of the speed of light (approximately 230,000 km/s). In 1694, Edmund Halley estimated the speed at 300,000 km/s, which was very close to the scientifically accepted value.

Note 4c.

By surveying different quadrants of the night sky, Herschel established that the stars surrounding the earth were distributed in the shape of a flattened disc. During the eighteenth century, when he did this work, neither he or other astronomers conceived of those stars as a unified gravitationally bound structure, what astronomers today would call a galaxy. Nevertheless, by characterizing the shape of the cluster of stars around our solar system, he laid the foundation for characterizing the galaxy in which our solar system resides, what astronomers now call the Milky Way galaxy.

Note 4d.

Typically, for nearby stars, astronomers use a method for measuring distance known as stellar parallax. This method measures the amount of angular displacement—or change in the apparent position—of the star or other object in the night sky when viewed from Earth at two different times six months apart—that is, when the Earth is at two opposite ends of its orbit around the Sun. This method uses triangles and simple trigonometric formulas to compute distance based on the measured angular displacement of the object during that six-month period. Unfortunately, astronomers a century ago could not use this method on Cepheid stars. That's because even the brightest, and thus likely closest, Cepheids then known did not generate discernable angular displacements that would have allowed for a direct parallax measurement. That left astronomers unable to measure the distance to even one Cepheid—until 1913, that is, when the Danish astronomer Ejnar Hertzsprung developed the new method for measuring distance known as *statistical parallax*. This method did not require the Cepheid stars to be as close to the Earth as the method of stellar parallax does. Even so, it did still require those stars to be *relatively* close to the Earth and certainly closer than the Cepheids in the Small Magellanic Cloud that Henrietta Leavitt studied. The method assumes that stars move in random directions, so the distribution of radial velocities, $\mathbf{V_r}$, (velocity moving directly toward or away from earth) and the distribution of tangential velocities, $\mathbf{V_t}$, (velocity perpendicular to the radial velocity) are roughly the same. The radial velocities can be calculated using the Doppler shifts in the stars' emitted light. The tangential velocities cannot be measured, but the angle, θ, that a star moves across the night sky over some time interval, **t**, can be.



As a result, astronomers can calculate the angular velocity, which is the rate at which the angle changes: $\mathbf{V_p} = \theta/\mathbf{t}$. This velocity is also known as the proper motion. The angle in radians by definition is equal to the distance, $\mathbf{d_t}$, an object travels tangential to the line of sight divided by the distance, **d**, to the object**:** $\theta = \mathbf{d_t}/\mathbf{d}$. The tangential distance is equal to the tangential velocity times the time: $\mathbf{d_t} = \mathbf{V_t}\ \mathbf{t}$. The first equation can be rewritten to show that the tangential distance is the angle times **d:** $\mathbf{d_t} = \theta\ \mathbf{d}$. Since the tangential velocity is $\mathbf{d_t}/\mathbf{t}$ and the proper motion is $\theta/\mathbf{t}$, both sides of the last equation can be divided by t to yield that the tangential velocity is equal to the proper motion times **d:** $\mathbf{V_t} = \mathbf{V_p}\ \mathbf{d}$. The distance to the group of stars can be determined by recognizing that the spread (standard deviation) of the radial velocities, $\mathbf{s_r}$, and that of the tangential velocities, $\mathbf{s_t}$, are the same. And, the spread of the tangential velocities is equal to the spread of the proper motions, $\mathbf{s_p}$, times **d** ($\mathbf{s_t} = \mathbf{s_p}\ \mathbf{d}$) since each velocity is **d** times the corresponding proper motion. The distance can now be directly calculated as follows: $\mathbf{d} = \mathbf{s_t}/\mathbf{s_p} = \mathbf{s_r}/\mathbf{s_p}$. Hetherington, *Encyclopedia of Cosmology: Historical, Philosophical, and Scientific Foundations of Modern Cosmology*, 277-278.

Note 4e.

Recall also Levitt showed that the logarithm of the apparent brightness for Cepheids plotted against the logarithm of their periods generates a straight line. As a result, the average of the logarithm of the brightness and the average of the log of the periods for several stars will correspond to a point on that line. Hertzsprung found the log averages for the apparent brightnesses and periods of the Cepheids in the local cluster at the known distance. He then used the distance to convert apparent to absolute brightness for that point. See Fernie, “The Period-Luminosity Relation: A Historical Review,” 707. Technically, Hertzsprung used Levitt’s graph plotting the *logarithm* of apparent brightness and the *logarithm* the period of pulsation to determine the apparent brightness of a star in the Small Magellenic Cloud with the same period of pulsation as the average of the *logarithm* of the group near the Sun.

Note 4f.

In addition to a discrete pattern of spectral lines, stars and other objects can emit radiation with a more continuous distribution of wavelengths. A device called a photometer can measure the intensity of light (roughly how many photons are present in the radiation at different wavelengths) coming from a distant star or galaxy. It can then plot the distribution of these different intensities as a function of wavelength. Often, these plots produce smooth curves. For instance, stars model what physicists call "blackbodies," where a broad range of wavelengths are represented. When this happens, specific frequencies still stand out either as emission or absorption lines. Stars often contain elements in their outer layers that absorb the light coming from lower layers. As a result, different types of stars have characteristic broad-peaked black-body spectra with narrow absorption lines corresponding to the elements in the outer layer of the star—i.e., the ones that absorb light at their characteristic wavelengths coming from the lower layers. Further, both stars and galaxies have absorption-line spectra. Some galaxies also display emission lines. While stars make up the bulk of the light of a galaxy, galaxies also have nebulae (like the Orion Nebula near us) that produce emission-line spectra. Astronomers use spectrographs to record the spectra of stars and galaxies, but the Doppler shift is measured from both absorption lines and emission lines.

Chapter 5

Note 5a.

Eddington showed that the values for the cosmological constant and the curvature of the universe (as well as the mass-energy density of the universe) needed to be perfectly set to allow for a static universe. Even the slightest alteration in any of those values would cause the universe to either expand forever or contract back onto itself in a great cosmological "big crunch." As Eddington explained: "Working in conjunction with Mr. G. C. McVittie, I began some months ago to examine whether Einstein's spherical universe is stable. Before our investigation was complete we learnt of a paper by Abbé G. Lemaître which gives a remarkably complete solution of the various questions connected with the Einstein and de Sitter cosmogonies. Although not expressly stated, it is at once apparent from his formulae that the Einstein world is unstable —an important fact which, I think, has not hitherto been appreciated in cosmogonical discussions." (Nussbaumer, "Einstein's Conversion from His Static to an Expanding Universe," 5).

Note 5b.

In fairness, Hoyle's creation field was no more ad hoc than Einstein's cosmological constant or current ideas about an "inflaton" field driving an early rapid expansion of the universe. Indeed, like the cosmological constant and the inflaton field, Hoyle's creation field provides a good example of the use in physics of an unobservable entity postulated to explain observable effects. All three of these theoretical postulates are ad hoc in this sense. Mathematically, Hoyle's creation field represented a variant version of the cosmological constant, though one that acted locally and episodically rather than uniformly and more constantly. Ultimately, his concept of a creation field failed to attract widespread support in physics, not because it was ad hoc, but because it failed to explain (or predict or describe) relevant evidence as well as other such theoretical postulates. For example, on the basis of his theory Hoyle predicted both spontaneous proton creation and spontaneous proton decay—the latter of which has never been observed, despite heroic efforts to do so at the Super-Kamiokande, an underground neutrino observatory in Japan. See Miura, "Search for Proton Decay via $p \rightarrow e^{+}\pi^{0}$ and $p \rightarrow \mu^{+}\pi^{0}$ in 0.31 Megaton-years Exposure of the Super-Kamiokande Water Cherenkov Detector."

Chapter 6

Note 6a.

The weak energy condition states that for the singularity to hold, the energy of the universe must be positive or zero (energy density must be nonnegative). The strong energy condition states that for the singularity to hold, the energy density of the universe must at all times be greater than the negative value of the pressure caused by the motion of the energy in the universe—or, more technically, the energy density of the universe must be greater than the negative value of each principal pressure and the negative value of the sum all three principal pressures as described by the field equations of general relativity. These three principal pressures are the pressures generated by the motion of energy in the three spatial dimensions as depicted on some coordinate system with orthogonal axes. In their 1970 article "The Singularities of Gravitational Collapse and Cosmology," Hawking and Penrose simply refer to this latter (strong) energy condition as "the energy condition" and define it alternatively as the idea that "'gravitation is always attractive' (in the sense that neighboring geodesics near any one point accelerate, on average, toward each other)" (531) or the idea that "the energy density is nowhere less than minus each principal pressure nor less than minus the sum of the three principal pressures" (529). See also Hawking and Ellis, *The Large Scale Structure of Space-Time*, 88–96; Curiel, "A Primer on Energy Conditions."

Note 6b.

In 1994 Borde and Vilenkin first analyzed whether inflationary cosmology could avoid an initial singularity. They concluded that even if the inflaton field of eternal chaotic inflation models continued to produce new bubble universes into the future, the inflaton field and the universe would have had to first spring from a temporal singularity in the past. As they concluded, "Such models must necessarily possess initial singularities; i.e., the inflationary universe must have had a beginning." [Borde and Vilenkin, "Eternal Inflation and the Initial Singularity,"] Their proof of a singularity assumed general relativity and Einstein's field equations. Unlike the Hawking-Penrose-Ellis proofs, however, their proof required not a strong but only a weak energy condition. In their 1994 paper, they argued that inflationary cosmological models could meet such a condition. Then, after further analysis, they published another paper in 1997 in which they reversed themselves. There they argued that inflationary cosmological models did not actually meet the weak energy condition. Consequently, they concluded that "non-singular, past-eternal inflating cosmologies" remained a possibility. [Borde and Vilenkin, "Violation of the Weak Energy Condition in Inflating Spacetimes."]. Then basing their analysis on special relativity, they showed that the universe must have had a beginning even if inflation had occurred. [Borde, Guth, and Vilenkin, "Inflationary Spacetimes Are Incomplete in Past Directions."]

Note 6c.

The only proposed cosmologies that avoid the BGV theorem entail physically unrealistic features. Typically, the universes envisioned in these cosmologies would expand indefinitely in both time directions from a special compacted state. In other words, they envision a universe that must have been infinitely large in the infinite past and then undergone an infinite contraction until it reached an extremely compacted state. It then would have expanded into our known universe. These proposals have encountered numerous problems. Most important, the entropy of the universe would have had to have been extremely finely tuned from the infinite past to generate the observed low-entropy state of our universe. In addition, the collapse of the universe before the big bang would have also had to have been extremely finely tuned to generate (after "the bounce") the homogenous, isotropic universe we see today. [See Craig and Sinclair, "The Kalam Cosmological Argument," 143.]

Here's a passage from the Craig and Sinclair article that amplifies the above points and also includes an intriguing passage from a letter they received from George Ellis critiquing these models. Craig and Sinclair first observe: "Sure, it would seem that a model that posits a prior contracting phase certainly evades BGV—the time coordinate τ will vary monotonically from −∞ to +∞ as spacetime contracts for all τ less than 0. But how does that entail that models of this sort are in fact viable options?" They then report: "In a personal communication with James Sinclair, George Ellis identifies two problems that plague these models: 'The problems are related: first, initial conditions have to be set in an extremely special way at the start of the collapse phase in order that it is a Robertson-Walker universe collapsing; and these conditions have to be set in an acausal way (in the infinite past). It is possible, but a great deal of inexplicable fine tuning is taking place: how does the matter in widely separated causally disconnected places at the start of the universe know how to correlate its motions (and densities), so that they will come together correctly in a spatially homogeneous way in the future?? Secondly, if one gets that right, the collapse phase is unstable, with perturbations increasing rapidly, so only a very fine-tuned collapse phase remains close to Robertson-Walker even if it started off so, and will be able to turn around as a whole (in general many black holes will form locally and collapse to a singularity). So, yes, it is possible, but who focused the collapse so well that it turns around nicely?'"

Chapter 8

Note 8a.

To do this, he first used Penrose's estimate of the entropy of our galaxy. Penrose estimated the entropy as equivalent to the entropy of a million-solar-mass black hole based on the assumption that such a black hole resides at the center of our galaxy. Miller also used Penrose's estimate of the entropy per baryon in the black hole (i.e., the entropy increase or decrease that would result from a particle being added or taken away from the black hole at the center of our galaxy). Miller estimated that the entropy per baryon in that black hole is 10^{26} natural entropy units per baryon (by interpolating from Penrose's estimate of the entropy per baryon in the whole galaxy).

Next Miller calculated the entropy of the galaxy by multiplying the entropy per baryon by the number of baryons in that black hole. He knew that physicists had estimated that our star has 10^{56} baryons. Since the black hole was a million times larger, he multiplied the 10^{56} baryons per star by 10^{6} to get a figure of 10^{62} for the number of baryons in the black hole (i.e., the one presumed to be at the center of our galaxy). Thus, to calculate the entropy of the galaxy, he needed to multiply 10^{62} (the number of baryons in the black hole) by 10^{26} (the entropy per baryon). That product is 10^{88}.

Miller then adapted Penrose's method for calculating entropy fine tuning for the whole universe to calculate the entropy fine tuning of our galaxy. He realized that the degree of entropy fine tuning is given by the ratio of the number of configurations consistent with the entropy of the galaxy compared to the number of configurations corresponding to the maximum expected entropy of our galaxy. Miller assumed that the maximum expected entropy of our galaxy equaled the entropy of our galaxy if the whole of our galaxy were a black hole, since black holes are the most entropic known structures. He then used Penrose's estimate of the entropy per baryon for our galaxy (if the whole of the galaxy were a giant black hole.) That would define the maximum expected entropy value for the galaxy. Penrose had estimated that value at 10^{31} natural entropy units per baryon. Since our galaxy has 10^{11} stars and since there are 10^{56} baryons per star, the entropy for a galaxy-sized black hole is then 10^{67} baryons. Consequently, the entropy of a black-hole galaxy can be calculated by multiplying the 10^{67} baryons per galaxy by 10^{31} natural entropy units per baryon, which yields 10^{98} natural entropy units for a galaxy-sized black hole. That number then, again, defines the expected range of possible entropy values for our galaxy. Miller then realized that if he divided the number of configurations that correspond to the actual entropy of our universe by the number of configurations that correspond to the maximum expected entropy, he could then get a measure of the entropy fine tuning of our galaxy. Yet, the number of configurations in any system can be approximated as 10 to the power of the entropy. Since the entropy of our galaxy is 10^{88} and the entropy of the galaxy would be 10^{98} if it were a black hole, the entropy fine tuning of our galaxy can be calculated by dividing $10^{10^{88}}$ by $10^{10^{98}}$, which is just $10^{10^{98}}$(since $10^{10^{83}}$ represents a minuscule fraction of $10^{10^{98}}$). The same calculation could be performed for just our solar system to yield a fine tuning of $10^{10^{76}}$. Clearly, the entropy fine tuning necessary for life is vastly smaller than the entropy fine tuning of our universe: $10^{10^{123}}$, but it is still unimaginably extreme. In any case, the degree to which the universe is extravagantly finely tuned beyond what is necessary for life, but also fine-tuned in a way that is necessary for scientific discovery of the universe, suggests the hypothesis that the universe is designed for discovery.

Note 8b.

The number that Penrose has calculated—1 in $10^{10^{123}}$—to provide a quantitative measure of fine tuning of the initial conditions of the universe is the unimaginably precise. Specifically, his calculated *ratio* implies that for every arrangement of initial mass-energy that would result in a low-entropy universe like our own, there were $10^{10^{123}}$ other possible ways of arranging that same matter and energy that would not. Thus, as Paul Davies observes, "The present arrangement of matter indicates a very special choice of initial conditions." Or as he also states: "the arrow of time derives ultimately from the fact that the universe began in an exceedingly low-entropy (smooth) gravitational state, with almost all the gravitational activity concentrated in a single, orderly, dilatory mode, and only slight irregularities superimposed on this. This initial state was, therefore, from the gravitational point of view, exceedingly special and remarkable, yet an essential element in explaining the universe we perceive. Do we just leave it at that, and accept that the universe was born in an exceedingly unusual state? Or is there a deeper explanation?" ("The Arrow of Time").

Note 8c.

The estimate for the lowest degree of fine tuning of the cosmological constant (1 part in 10^{53}) is based on the estimate of fine tuning necessary to make an inflationary cosmological model viable. Indeed, the standard cosmic inflation model assumes that the early universe expanded rapidly for a minuscule fraction of a second due to an "inflaton" field permeating space. After the inflationary period, the inflaton field had to drop by a factor of 10^{53} to prevent the universe from expanding too quickly, so as to allow for the formation of galaxies, stars, and planets. The fine tuning of this inflaton shutoff energy provides the basis for calculations about the smallest degree of fine tuning necessary for the cosmological constant (though keep in mind that even 1 in 10^{53} represents an extraordinary degree of fine tuning). The estimate of the larger value is derived from actual measurements of the current rate of expansion of our universe. It suggests that the real value of the constant is 10^{120} times smaller than its expected value based on calculations from quantum field theory for the background energy of the universe. Most physicists now think that the lower bound estimate greatly underestimates the degree of necessary fine tuning of the cosmological constant.

Here's why. Theorists hoped that a new principle of physics known as supersymmetry would explain the low observed value for the vacuum energy of space. This theory proposes that the positive calculated contributions from matter fields would cancel out by symmetric negative terms. Physicists have not, however, discovered any evidence for this proposed adjustment to particle physics at the Large Hadron Collider. Consequently, most physicists now prefer to estimate the degree of cosmological constant fine tuning based on the universe's observed expansion rate (Sahni and Starobinsky, "The Case for a Positive Cosmological Lambda-term," 373–422).

Note 8d.

Most physicists now commonly agree that the degree of fine tuning for the cosmological constant is *no less than* 1 part in 10^{90}. Here's why: the cosmological constant acts as a repulsive force that works against gravity. It is believed to result from the sum contributions from matter fields and a "bare" cosmological constant. Some factors are positive and some are believed to be negative. They have to almost perfectly cancel each other out to obtain the very small value measured today. (See Collins, "Evidence for Fine-Tuning," 180–82, n. 8.) These estimates are based on determinations of how much the cosmological constant could change before the universe could no longer support life. A safe estimate comes from assessing the relationship between the constant's value and the time it would take before the cosmological constant would become the dominate factor in determining the expansion rate. That time was calculated to be proportional to the square root of the constant. (See Weinberg, "Anthropic Bound on the Cosmological Constant.")

If the constant were larger by a factor of 10^{30}, it would become the dominant factor in determining the expansion rate only 6 minutes after the big bang. As result, the expansion rate of the universe would increase too quickly to produce elements heavier than hydrogen. Indeed, in that case, the universe would have been a dilute soup of hydrogen atoms rarely even colliding with each other. Clearly, no complex structures such as galaxies could have formed in such a universe and so life could not exist. Conversely, if the constant were larger by that same factor of 10^{30} but negative, the universe would have quickly contracted back into a dense mass of superheated particles that also would have prevented the formation of life. Thus, increasing the value of the cosmological constant by a factor of 10^{30} in the positive or negative direction would certainly make life impossible in the universe.

Consequently, most cosmologists accept that the cosmological constant was finely tuned to one part in 10^{90}. They arrive at that number by dividing 10^{120} (the maximum expected range of values for the cosmological constant based upon quantum field theory) by the 10^{30} (which defines the maximum acceptable range of variation in the value of the constant consistent with life in the universe). That calculation yields still exquisite fine tuning of 1 in 10^{90} (i.e., 1 part in $10^{120}/10^{30} = 10^{90}$).

Chapter 9

Note 9a.

The most logical place to look for self-organizing properties to explain the origin of genetic information is in the constituent parts of the molecules carrying that information. But biochemistry and molecular biology make clear that the forces of attraction between the constituents in DNA, RNA, and proteins do not explain the sequence specificity (the information) present in these large information-bearing molecules. This can be seen most readily via a simple counterfactual. Any molecular biology textbook will, in a few introductory paragraphs early in the text, review the organic chemistry of nucleic acids and proteins. Now, if these basic chemical facts were causally sufficient to explain the detailed functional specifications necessary to the living state discussed in the remainder of the textbook (e.g., the genetic code, RNA and DNA polymerases, transcription, translation, the ribosome, gene structure in prokaryotes versus eukaryotes), straightforward derivations would be presented: "From the organic chemistry of nucleic acids, it follows that genes begin with start codons ...," and so on. Of course, this never happens, and for good reason. Life presupposes and utilizes chemistry, but it is not *explained* by chemistry. For more demonstrations of this fact, see Chapter 14 of *Return of the God Hypothesis*. See also: Meyer, "The Difference It Doesn't Make: Why the 'Front-end Loaded' Concept of Design Fails to Explain the Origin of Biological Information." 209-228.

Note 9b.

Of course, the phrase "large amounts of specified information" raises a quantitative question, namely, "How much specified information would a bio-macromolecule (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 *de novo* emergence of roughly 500 or more bits of specified information reliably indicates intelligent design in a prebiotic context. Here's how I demonstrate that.

In Chapters 8-10 of *Signature in the Cell*, I calculate the probability of the chance origin of a single protein fold of modest length. As discussed there and in Chapter 10, note 23 of *Return of the God Hypothesi*s, protein folds constitute the smallest unit of *structural* innovation in the history of life. Since a minimally complex living cell requires at least 250 separate functional proteins, and since individual specific functional proteins depend upon the existence of stable protein folds, explaining the origin of protein folds is a necessary condition of explaining the origin of proteins and, thus, the origin of the first living cell.

In Chapters 8-10 of *Signature in the Cell*, I show that random interactions of amino acids are overwhelming more likely to fail, than to succeed, in producing even a single protein fold of modest length in the 13.8 billion year history of the universe. I base my calculations in part upon the site-directed mutagenesis experiments of Douglas Axe who established a precise quantitative estimate for the rarity of amino acid sequences that result in stable protein folds within amino acid "sequence space"—i.e., the total number of possible combinations of protein-forming amino acids of a given length. Axe showed that for every sequence of amino acids of a given modest length (of 153 amino acids in his case) that does result in a function-ready protein fold there are 10^{77} amino acid sequences that do not fold—and, thus, cannot perform any biological function. (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.")

Axe's work, plus calculations of the probability achieving two other conditions of proper protein folding (the presence of exclusively "left-handed" or "homochiral" amino acids in a polypeptide chain and the exclusive presence of peptide bonds between the amino acids in such a chain), makes possible a precise calculation of the probability that random interactions between amino acids would produce a function-ready protein fold in the history of the universe. In *Signature in the Cell*, I calculated that probability at 1 in 10^{164}.

Yet, I also showed that at most only 10^{139} events have occurred since the beginning of the universe where an event is defined minimally as an interaction between elementary particles. It follows from these two calculations that if every event in the history of the universe had been a random interaction between one of the 20 protein-forming amino acids (a ridiculously generous assumption), such a random process would only have been able to generate or "search" 1 ten trillion, trillionth (i.e., $1/10^{25}$ or $10^{139}/10^{164}$) of the total number of relevant amino acid sequences in the entire history of the universe. That means that random searches of amino acid sequences are overwhelming more likely to fail, than to succeed, in producing even a single protein fold of modest length in the time since the big bang. And that implies that the chance hypothesis that such a search did succeed is overwhelmingly more likely to be false than true. In other words, chance alone is insufficient to produce *the amount of information* present in a protein fold of modest sequence length (or in a section of DNA capable of producing one).

Notice that in making this calculation, I assumed that given the number of random interactions that could have occurred since the beginning of the universe, a great number of possible combinations of amino acids might arise by chance. But I show the number of such combinations that could thus arise is miniscule in comparison to the number of possibilities that would need to be searched in order to have a reasonable (better that 50%) chance of producing (or "finding") a sequence of 150 amino acids that will result in a stable fold.

My analysis thus acknowledges that for molecules containing less information, with a less prohibitively large corresponding space of possibilities to search, a random search might possibly succeed. But that raises a question: Where is the cutoff between a plausible and an implausible random search? How much information could chance alone—in the best case—produce?

Dembski has calculated what he calls a universal probability bound to establish that point of absolute demarcation. He estimates the maximum number of events that could occur in the history of the universe (where, again, an event is defined minimally as an interaction between elementary particles). He estimates that 10^{150} such events could have occurred since the beginning of the universe. He derived that number by multiplying the number of elementary particles in the universe (10^{80}) by the number of seconds since the big bang (10^{17}) by the maximum number of interactions that can occur between elementary particles in a second (10^{43}) to get 10^{140} total possible events. (Dembski rounded that number to 10^{150}, but I use the more precise estimate of 10^{139} in *Signature in the Cell*). That implies that the occurrence of any event that would require more than 10^{150} (or 10^{140}) random trials to have a better than 50% chance of occurring, cannot be *plausibly* explained by chance alone.

Now recall that probability is inversely related to information by a logarithmic function. Thus, a probability of 1 in 10^{150} corresponds to an input or presence of approximately 500 bits of information. That implies that any event with a probability of 1 in 10^{150} or less would require an input of 500 bits of information or more—and that amount of information exceeds what chance alone can plausibly be expected to produce. (The more precise small probability bound of 1 chance in 10^{140} implies that any event with a probability of 1 in 10^{140} corresponds to a needed input or presence of 462 bits of information).

Chance alone, therefore, does not constitute a plausible explanation for the *de novo* origin of any specified sequence or system containing more than 500 (or, more precisely, 462) bits of (specified) information. Many (indeed most) protein folds, including many that are absolutely necessary to sustain even simple one-celled organisms, contain more information than that.

Moreover, I show in *Signature in the Cell* in Chapters 11-12 that information-rich molecules and systems lacking redundant order defy explanation by self-organizational laws and processes. I also show there in Chapters 13-14 that appeals to prebiotic natural selection presuppose, but do not explain, the origin of the specified information necessary to produce a minimally complex self-replicating RNA molecule or to produce a molecular or cellular system. (I summarize these arguments in Chapter 9 of *Return of the God Hypothesis*). Therefore, I conclude that intelligent design best explains the origin of any molecule or system with more than 500 (or 462) bits of specified information—at least when the production of such a system requires starting from a purely physical-chemical (as opposed to biological) set of antecedents. Since modest length functionally necessary protein folds exceed that threshold, I conclude intelligent design best explains the origin of the information necessary to produce them in a prebiotic context.

Chapter 10

Note 10a.

The late invertebrate paleontologist David Raup was a professor of evolutionary theory at the University of Chicago, curator of geology at the Field Museum, and member of the National Academy of Sciences. In a widely cited article, Raup summarized the consistent signal emerging from the fossil record: "We are now about 120 years after Darwin and the knowledge of the fossil record has been greatly expanded. We now have a quarter of a million fossil species but the situation hasn't changed much. The record of evolution is still surprisingly jerky and, ironically, we have even fewer examples of evolutionary transition than we had in Darwin's time. By this I mean that some of the classic cases of darwinian [*sic*] change in the fossil record, such as the evolution of the horse in North America, have had to be discarded or modified as a result of more detailed information—what appeared to be a nice simple progression when relatively few data were available now appears to be much more complex and much less gradualistic. So Darwin's problem has not been alleviated in the last 120 years" ("Conflicts Between Darwin and Paleontology," 25).

Harvard paleontologist and evolutionary biologist Stephen Jay Gould also famously expressed doubts about the accuracy of the gradualistic Darwinian depiction of life's history because of the discontinuity evident in the fossil record. ("Is a New and General Theory of Evolution Emerging?" 120). With fellow paleontologist Niles Eldredge, he formulated an alternative theory of evolution called "punctuated equilibrium" to account for the pervasive pattern of "abrupt appearance" and "stasis" (or lack of any directional change in form) in the fossil record. "Punk eek," as it was affectionately known, fell out of favor during the 1990s, however, because it failed to offer a mechanism capable of explaining the abrupt appearance of new forms of life in the fossil record. Nevertheless, Gould's high-profile dissent from neo-Darwinism based upon the evidence of fossil discontinuity led other evolutionary biologists to express their doubts more openly as well. For a more complete discussion of this topic see: Meyer, *Darwin's Doubt*, 3-152.

Chapter 11

Note 11a.

Here's another example that illustrates the way both explanatory power and considerations of simplicity contribute to the evaluation of competing possible explanations. Once a week, Mrs. Smith places several items in her oven to bake just before she leaves to do her shopping. One morning she returns to find that all of these—a cake, a loaf of bread, and a popover—have failed to rise. Drawing on past experience of cause and effect, she initially suspects two possible causes: faulty leavening agents or low oven temperature. The first of these seems unlikely to her, because each of the items baked that morning relies on a different leavening agent: the cake is leavened by baking soda, the bread by yeast, and the popover by steam. Given her background knowledge, she judges it unlikely that each of these leavening agents would have suddenly turned defective on the same day, each for a different reason.

This leads Ms. Smith to suspect the oven. But then she realizes that because the cake was leavened by baking soda, it would have risen even if the oven had not been heating to full temperature. In fact, if the oven had not been heating properly, she would have expected to find the cake rising, but less than fully cooked when she returned. As she found the cake fully baked but fallen, she concluded that, while a faulty oven might explain why the bread and the popover didn't rise, it couldn't explain the cake. In other words, the faulty oven hypothesis did not cite an adequate cause for the failure of the cake to rise.

This leads her to suspect another cause. She wonders if perhaps some jarring or shaking might have caused *all* the baking goods to fall. Our baker friend then remembered that her upstairs neighbor, Mrs. Jones (wife of the above-mentioned Mr. Jones), loves to work out to televised aerobics. Smith also remembers that Mrs. Jones generates a significant amount of noise and vibration in Smith's apartment when she works out. Smith consults her online listing to find out that the TV exercise program has recently been changed from Monday to Tuesday morning at exactly the time she was shopping. She infers that her neighbor's aerobic jumping during the Tuesday morning program caused the bread, the popover, and the cake to fall.

Mrs. Smith's inference explained many diverse facts with a single (economical) and causally adequate postulation. Her inference took advantage of her knowledge of cause and effect. It also did so without multiplying unnecessary causal postulations. Recall that Mrs. Smith eliminated one of the possible causes, the faulty oven hypothesis, because it lacked causal adequacy as an explanation of one of the relevant facts, the failure of the cake to rise. She also eliminated (or simply ignored) several more complex or convoluted hypotheses. She did not, for example, seriously consider the option that the cake fell because of bad baking soda *and* the popover and bread fell because of a faulty oven. Though logically possible, this seemed—based on her background knowledge of how the world works—unlikely and unnecessarily complex.

Similarly, she eliminated the hypothesis that all three items failed because their leavening agents had gone bad, in part, because it seemed unlikely to her that all three baked items would have fallen for different reasons when cooked simultaneously in the same oven and also, in part, because such a complex explanation ultimately proved unnecessary. Instead, she preferred the inference that could explain each of the relevant facts by reference to a single economical causal postulate—her neighbor was jumping above her oven on Tuesday morning. Her reasoning thus illustrates the way attempting to explain the most facts with the fewest causal postulates (i.e., most simply in that sense) can help to eliminate possible competing hypotheses and diminish the uncertainty associated with a single abductive inference.

Note 11b.

A Primer on Bayesian Probability Calculus

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Speaking the Language of Probability

P(H) "The probability of H." This expression stands for a number that (by the rules of probability) must lie between 0 and 1, inclusive. "H" here stands for a proposition, usually (for ease of recognition) a hypothesis. In the context of Bayesian reasoning, P(H) is called "the prior probability of H" or, more simply, "the prior," by contrast with P(H|E).

P(~H) "The probability of not-H." Another number between 0 and 1. Since "not-H" here is simply the falsehood of H; the expression could therefore also be read "The probability that H is false." By the axioms of probability, P(H) + P(~H) = 1, so the higher the one, the lower the other.

P(H|E) "The probability of H, given that E." This is a conditional probability; we can understand it as the probability that H *would* have if E *were* true. The model operating in such cases is that we begin with no direct information about E and then learn that E (but nothing else relevant). In the context of Bayesian reasoning, P(H|E) is sometimes called "the posterior probability of H" because it represents the probability that H would have *after* we learn that E.

P(E|H) "The probability of E, given that H." This is another conditional probability, understood as the probability that E *would* have if H *were* true. In the context of Bayesian reasoning, P(E|H) and P(E|~H) are called "likelihoods."

P(E) "The probability of E." This is a number that indicates the expectedness of the evidence E. The lower P(E), the more surprising it would be and (all else being equal) the greater the boost that E can give to H if P(E|H) >> P(E|~H).

Once we learn (for certain) that E, the new probability $P_{new}(E) = 1$, and $P_{new}(H) = P(H|E)$.

Deriving Some Versions of Bayes's Theorem

One of the basic axioms of probability is the conjunction rule: P(E&H) = P(E) P(H|E) = P(H) P(E|H). As long as P(E) > 0, we can divide both sides by that quantity, which (with a little rearrangement) yields the equation

P(H|E) = P(H) P(E|H)/P(E)

If we write out this simple version of Bayes's Theorem twice, once in terms of H and once in terms of ~H, we get:

P(H|E) = P(H) P(E|H)/P(E)

P(~H|E) = P(~H) P(E|~H)/P(E)

We can then take the ratios of the left and right sides respectively—the term P(E) will cancel out—giving us the Odds Form of Bayes's Theorem:

P(H|E)/P(~H|E) = P(H)/P(~H) * P(E|H)/P(E|~H)

For the purpose of giving a mathematical reconstruction of IBE, the Odds Form is the version we usually want to use.

Note 11c.

One objection to the use of the Bayesian formalism to evaluate hypotheses is known as the "problem of old evidence." This problem arises when scientists discover that some hypothesis H long under consideration implies that some already known fact E would be expected. Since the fact in question is already known, it is hard in the Bayesian formalism to know how to "update" assessments of the probability of the fact given the hypothesis—i.e., the so-called likelihood of the fact given the hypothesis—and, therefore, also difficult to know how to update assessments of the probability of the hypothesis H in question. Nevertheless, philosophers of science have provided technical solutions to this puzzle that allow assessing how much a piece of evidence *would have* increased support for a hypothesis, had we come to know it after the fact of forming a theory rather than before it. See Elles and Fitelson, "Measuring Confirmation and Evidence"; "Symmetries and Asymmetries in Evidential Support." For another proposed solution to this puzzle, see Christensen, *Putting Logic in its Place*. See also Talbott, "Bayesian Epistemology."

Chapter 12

Note 12a.

The classic statement of the Kalam cosmological argument for God's existence uses such a standard deductive form:

Whatever begins to exist has a cause
<u>The universe began to exist</u>
Therefore, the universe has a cause of its existence.

The standard statement of the Kalam argument is actually an example of what logicians call an enthymeme. Enthymemes are arguments that omit a step often by leaving a deductive entailment relationship unstated. In this case, the full argument should be stated as follows:

For all X, if X begins to exist then X has a cause
If the universe begins exist, then the universe has a cause
<u>The universe began to exist</u>
Therefore, the universe had a cause.

The first premise in this argument involves a move that logicians call "universal instantiation." The second and third statements form a standard *modus ponens* argument with a deductively valid conclusion. This more complete formulation of the argument also provides an excellent example of an entailment relationship. Thus, the points made about the shorter version of the *kalam* argument apply equally to this more complete version.

Chapter 13

Note 13a.

Physicist Luke Barnes formulates the fine tuning argument slightly differently than I do. 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 (and 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 $p(E|T_1B) \gg p(E|T_2B)$, then E strongly favours T_1 over T_2.

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

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

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

Note 13c.

Recall from Chapter 13 endnote 5 above that Barnes takes a slightly different tack 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. 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 that the fine tuning provides greater evidential support for theism than naturalism.

Note 13c.

Indeed, according to some forms of eastern pantheism, for example, one school of Vendanta Hindusim known as the Shankara school, even our own awareness of ourselves as conscious minds separate from the oneness of nature (*Brahman*) represents an illusion or false consciousness. As John Kohler notes, according to the Shankara school, "*Brahman* alone is real, the world being merely an appearance." Other schools of Vendanta, such as the Vishistadvaita school of the philosopher Ramanuja taught that "the world is real but is not different than *Brahman*, since *Brahman* is the unity of differences that constitute the world." In pantheistic religions the spiritual disciplines often serve to rectify the false awareness of our own existence as entities separate from the Oneness of the impersonal world. Either way, as Kohler notes, "according to the Vendanta, the Upanishads (sacred Hindu treatises written between 800 and 200B.C.E.) taught that experiencing the ultimate reality was through liberating the innermost self, the *Atman*, from its embodiment in mind and body." With self-annihilation the goal of much Eastern meditative practice, neither mind or intelligence is regarded as having much ultimate "ontological status" or reality, though many versions of Hindu thought recognize the distinction between sentient beings such as ourselves and the non-sentient, impersonal and (and ultimately real) universe. See Kohler, *Asian Philosophies*, 81.

Chapter 14

Note 14a.

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. [Lev Vaidman, "Quantum Theory and Determinism," 5–38.] Therefore, in 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 into 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. Such omniscience would seem to depend upon God having total control over future quantum events—precisely the kind of involvement in the creation that deists deny.

A deterministic front-loaded design hypothesis based upon hidden variables also seems scientifically implausible due to the chaotic dynamics that govern the interactions of large systems of particles. [See: Ch. Dellago and H.A. Posch, "Kolmogorov-Sinai Entropy and Lyapunov Spectra of a Hard-Sphere Gas," 68–83].

Here's why: According to chaos theory, any alteration in initial conditions of the hidden variables would result in new outcomes that would diverge dramatically and exponentially over time from the originally intended outcome. Yet designing a cell (or multiple cells and more complex organisms) from the beginning of the universe would require setting many hidden variables/initial conditions for many different intended outcomes in a highly sequential order. And some of the required initial conditions for generating one state (e.g. first prokaryotic cell) would likely conflict with the conditions necessary for generating another (e.g. first eukaryotic cell). Indeed, the more necessary outcomes and conditions the greater the risk that the separate constraints necessary to produce separate specific outcomes would conflict. At the very least the conditions required for generating one outcome might require slight tweaks to the conditions to ensure the arrangements of matter necessary for another specified outcome to arise. Further, the more conditions the origin of life and the origin of later organisms require, the greater the probability that some such design tradeoffs would be necessary. And given what we know about life, many such conditions and biochemical subunits—sugars, phosphates, nucleotides, amino acids, lipids, galaxies, stable solar systems and a host of planetary fine-tuning parameters—need to be present and/or set just right. If, hypothetically, the designer having set the hidden variables for one condition, then needed to tweak them a bit to accommodate some other necessary condition of life, those tweaks would, according to chaos theory, produce huge deviations from the originally intended outcome making it unlikely the first intended outcome would still arise. Yet, likely, many such design tradeoffs in the initial conditions of the universe would need to be made. And the need for such tweaks implies that relying on the laws of nature to transmit the initial design plan with fidelity and without degradation, given chaotic processes, is implausible in the extreme. Indeed, making provisions to produce all necessary parts and environmental conditions for the origin of life and for later organisms billions of years in advance, when each of the pre-specified parts, systems or states might also interact with each other and generate "butterfly effect" like deviations from the original design plan, seems an unrealistic way to create and transform life. Indeed, quite possibly no choice of initial conditions could realistically ensure the formation of even the first cell far into the future since that result would require countless specific coordinated outcomes and depend upon many unimaginably precise finely tuned and, likely, *mutually exclusive*, initial conditions. Moreover, the quantum principles of gravity that would likely apply in the earliest stages of the universe would most probably quantize space, time, and/or other variables in such a way as to prevent the initial conditions from even being set with the near absolute precision required to achieve the desired results so far in the future. Still, I suppose, an omniscient God could in theory overcome such a constraints problem. Yet, to do so would require vastly more intelligent intervention, fine tuning and informational input than would be required to create a cell at the desired time after all the necessary environmental and biochemical conditions had already been established. Given our knowledge of complex systems physics, specifying initial conditions and hidden variables at the beginning of the universe would seem to be a clumsy, and anything but parsimonious, way to create life.

Extended research note 14 b.

There may be an even deeper problem with the front-loaded design hypothesis of Dennis Lamoureux and others. This hypothesis 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. Computational processes apply algorithms to specified initial conditions in order to converge on a specific outcome after which the process in question stops or "halts." Front-loaded design proponents effectively envision the laws of physics functioning as an algorithm that can be applied to preprogrammed cosmological initial conditions. They then envision this process converging at the production of a living cell (and possibly other more complex forms of life). Yet, there are significant reasons to doubt the Church-Turing conjecture as front-end design proponents apply it, especially given that the conjecture remains unproven in computer science. First, the processes of cosmogenesis (or cosmic evolution) and biogenesis do not appear to qualify as computational processes in the sense of the Church-Turing conjecture. Computational processes represent "one-to-one" or "many-to one" processes that terminate or halt at a single final state. Yet, both cosmogenesis and biogenesis are "one-to-many" processes that either terminate with many different states (both living and non-living) or may not terminate on a solution at all (i.e., they may be computationally undecidable). Thus, processes of cosmogenesis and biogenesis may not qualify as as computational processes since to do so a process must apply an algorithm to specified initial conditions to generate a *specific* outcome. Then, after doing so, it must halt. Clearly, the universe as we see it manifests many complex outcomes and structures, particularly in the living world. Moreover, the fossil record shows that the appearance of increasingly complex structures did not halt after the origin of life. Instead, as Georgetown mathematical biologist Paul Kainen has quipped, "Life is physics running backwards" by which he means that life arises in a multiplicity of manifestations from a single initial state or set of initial conditions, whereas physics describes one-to-one or many-to-one outcomes where the laws of physics act on specific initial conditions and generate specific solutions. See Kainen, "On the Ehresmann–Vanbremeersch Theory and Mathematical Biology," 225–244, esp. 241. I'm indebted to my colleague Richard von Sternberg for introducing, and explaining, this argument to me.

Extended research note 14 c.

In addition to Harthshorne's version of panentheism, some contemporary "open theists" describe themselves as panentheists, though they explicitly deny that God's existence depends on the physical world. Since their version of panentheism affirms both the genuine transcendence and immanence of God, it represents a variant version of classical theism. In fact, these open theist/panentheists differ from many other traditional theists mainly in that they deny that God knows the future as it concerns the choices of free libertarian actors such as ourselves. Since the opponents in this debate about God's knowledge of the future all presuppose the existence of a personal, intelligent and transcendent God with libertarian freedom of His own, it does not bear on the strength of my scientific case for the existence of such a being. Consequently, I will leave issues about what exactly God knows about the future to the theologians. For our present purposes, suffice to say that to the extent that panentheism is consistent with classical theism, panenetheism could offer a causally adequate explanation for the key evidences concerning biological and cosmological design addressed in *Return of the God Hypotheses*. But to the extent panentheism breaks with classical theism, by, for example, denying the independence of God from the physical universe, it fails the test of causal adequacy and lacks explanatory power.

Extended research note 14 d.

In the *Return of the God Hypothesis*, chapter 14 n. 35, I offer a few thoughts to establish a framework for addressing the objection to arguments for the existence of God based on the presence of "natural evil" in the world. I argued there 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. Moreover, I also suggested that the presence of natural evil actually confirms certain kinds of theistic hypotheses, in particular those based upon a Judeo-Christian understanding of nature. I reprise some of those points here and extend that analysis at the end of this note by examining a logical fallacy that can prevent some people from perceiving the explanatory resources associated with some versions of theism, in particular a biblical or Judeo-Christian versions.

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 non-religious 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 or 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 bio-macromolecules and information processing systems in cells as well as the miniature machines and circuitry in cells—but they are also discovering evidence 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 S.R., 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 S.R and Rohde H.N. "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, bacteriologists now know that *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. 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." [Rasmussen, et al., "Early Divergent Strains of *Yersinna pestus* in Eurasia 5000 years ago." 571-582.]

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 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) Thus, this dual aspect of nature provides a confirmation of the Judeo-Christian worldview or a specifically Judeo-Christian intelligent design 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—one that runs like this: If E is evidence against some theory T, and if some more comprehensive claim C has T as one of its logical consequences, then E is evidence not just against T but against C as well. In this context, that fallacy would take this form: "If the existence of natural evil is evidence against traditional theism, and if Christianity entails traditional theism (and of course much more besides), then evil must be evidence against Christianity." Since former Princeton University philosopher of science Carl Hempel's critique of what is known as "the converse consequence condition" back in the middle of the 20th century, logicians and philosophers have realized that the above conclusion simply does not follow from these premises. (Hempel, Carl Gustav & Oppenheim, Paul (1948), "Studies in the Logic of Explanation." 135-175.] In this context, the applicable point is that some specific versions of theism have more resources than others for dealing with the problem of natural evil. So long as we keep theism in soft focus, blurring out the details that distinguish one form of theism from another, we can easily lose sight of this fact. Some versions of theism, notably the Judeo-Christian version, explicitly affirm a "fallen" or partially broken physical world, one that is not now as it was first intended or designed to be. 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. Indeed, our encounter with such natural evil actually provides evidential support for the Judeo-Christian understanding of nature considered as a kind of metaphysical hypothesis.

Chapter 15

Note 15a.

Here's a partial transcript of my dialogue with Charles Marshall on the Justin Brierly Program *Unbelievable* with time codes of the relevant portions:

Time code: 40:15

Charles Marshall: So let me just see if I can attack this problem with something that Stephen said, which is he can't see how you can take a gene regulatory network from one body plan and change it into the gene regulatory network of another body plan, because those networks now are committed to being a fly or a sea urchin or a jellyfish. And I couldn't agree more. He's precisely correct. But now we get to the unfolding issue. If we wind back the evolutionary clock far enough, we have just single-celled organisms, and then after a while, we start to get small colonial organisms, and then after a while they get large enough that they start to look like the first animals. And those first animals that are alive and well today are called sponges, and what is remarkable about sponges is that they do not have tissues, they do not have organs. They have essentially the same set of genes as a drosophila, as a jellyfish, and a human. But they do not have tissues, they do not have organs. And so you have then the genes that have the capacity to make tissues and organs sitting there, and so what we think happened in the Cambrian explosion is we had different lineages independently acquiring different body plans. Once those body plans are in place, then selection holds them in place and then future genes are added to them, making that impossible…

Stephen Meyer: "…he's still helping himself to the informational endowments that make those processes possible."

44:15

Charles Marshall:

Ok, so I think that's a very good point. And so what I'd like to note is there's a subtle shift in ground. And I'm not trying to deny the point that Stephen just made. In his book, which I read, the emphasis was on the creation of the new genetic information, and he placed that at the time of the Cambrian explosion. And so in my Science review, I responded to that specific claim. And so what Steve seems to be saying now that he is ok with the idea that in fact that genetic information may have had its origins elsewhere. *And so, so fair enough.* So then you have to address the question, where does that genetic information actually have to come from in the first instance, and I think that's a very important and critical point. And so it's less to do now with the Cambrian explosion, per se, it's less to do with Darwin's Doubt and the sudden emergence of fossils at the base of the Cambrian, it's more to do now with *where does the genetic information and the epigenetic information come from that makes animals, organisms, plants, and so I think that's a very important point. (Emphasis added)*

Note 15a.

A close reading of Venema's discussion of nylonase and his critique of Axe's claim about the rarity of protein folds shows that he does not understand the complex protein structure typical of enzymes. In his article, Venema claims that "Nylonase is *chock full of protein folds*—exactly the sort of folds Meyer claims must be the result of design because evolution could not have produced them even with all the time since the origin of life" ("Intelligent Design and Nylon Eating Bacteria," emphasis added). Venema's phrasing reveals ignorance on two counts. First, nylonase has a particular three-dimensional structure composed of two domains, each of which exemplifies a distinctive fold. A protein domain or fold is a distinctive, stable, complex, three-dimensional "tertiary" structure made of many smaller "secondary" structures such as alpha helices or beta strands. Some compound proteins may have more than one unique domain or fold, each exhibiting a unique tertiary structure, though many proteins are characterized by a single fold or domain. In any case, no protein chemist would describe nylonase as "chock full of protein folds," since it has just *two* distinct domains. In addition, since proteins are *characterized* and distinguished *by their folded structures*, it also betrays confusion to describe them as if they were receptacles for "holding" folds or as if folds were mere constitutive elements of a protein. That would be like saying that cars are "chock full" of chassis, or animals "chock full" of bodies. Even so, protein folds including nylonase *are* composed of (or "chock full" of) many smaller units of secondary structures such as alpha helices or beta strands—which is probably what Venema is referring to and probably why he exaggerates the significance of the origin of nylonase even though nylonase originated by just two mutations in a *pre-existing* gene for a *pre-existing* protein fold. Venema also references the origin of peptide chains that performed some simple function, such as sticking to a molecule, but he fails to appreciate that those chains do not have the characteristics typical enzymes. Therefore, their origin has no relevance to the rarity of proteins as complex as those necessary to genuine biological innovation and those studied by Axe.

Chapter 16

Note 16a.

The earliest version of string theory only offered a description of the bosons that carry the strong nuclear force, and it required 26-dimensional spacetime in order to work. So as initially formulated, string theory was bosonic, 26-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. All particles, whether matter or radiation, have a property of intrinsic quantum spin that emerges from quantum mechanics. For matter particles, this spin is quantized in half-integral (i.e., +/- ½, +/- 3/2) units, and for radiation it is quantized in integral (e.g., 0, +/- 1, +/- 2) units. Half-integral spin particles are called fermions and integer spin particles are called bosons. As explained below, invoking the idea of supersymmetry in a mathematical structure constrained by quantum-mechanical relations enabled the extension of string theory to include all matter and radiation in 10-dimensional spacetime.

Note 16b.

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. Moreover, making demarcations between scientific and metaphysical hypotheses can be difficult in part because both science and metaphysics (or philosophy) attempt to gain knowledge about, or explain, the nature of reality. Even so, by convention we designate hypotheses offering ultimate explanations, or explanations with deeper worldview implications, as metaphysical, even if their proponents cite empirical or scientific evidence about the natural world in support of them. Conversely, we typically designate theories that describe, classify and explain natural phenomena as scientific. We also designate theories about the origin of the universe and life as scientific, even though such theories may also have larger implications for deep worldview questions. Given these conventions, I am happy to concede that the God hypothesis as formulated here constitutes a metaphysical hypothesis. Interestingly, many physicists now say the same about the multiverse, though they often do so as a way of disparaging the hypothesis as an untestable speculation. I certainly agree that physicists cannot test the multiverse hypothesis in the laboratory under controlled and repeatable conditions. Nevertheless, I do not agree that just because a hypothesis involves an unobservable entity, that it cannot be tested or rationally evaluated. Scientists have tested and adopted many theories positing unobservable entities including theories in molecular biology, evolutionary biology, theoretical physics and cosmology. Nor do I think that just because a metaphysical hypothesis posits some entity (or entities) as the prime reality, as clearly both multiverse hypotheses and the God hypothesis do, that they cannot be tested or evaluated. One important way to evaluate such hypotheses, as we have seen, is to compare their explanatory power to that of their competitors. For an extended discussion of the so-called demarcation issue see Chapter 11 and Meyer, "Sauce for the Goose: Intelligent Design, Scientific Methodology, and the Demarcation Problem," 95–131; Meyer, "The Scientific Status of Intelligent Design: The Methodological Equivalence of Naturalistic and Non-Naturalistic Origins Theories," 151–211; Meyer, "The Demarcation of Science and Religion," 12–23.

Note 16c.

Some of the fine tuning necessary to the function of the inflationary universe-generating mechanism could in theory result from the process of randomizing initial conditions as inflation shutoff energies generate an infinite number of bubble universes. This would, however, create a kind of cosmic chicken-and-egg problem by raising the question: "Which came first: the spacetime-energy structure of the inflaton field that makes a universe-generating mechanism possible or a universe-generating mechanism that produces inflaton fields with the right spacetime-energy structure?" Arguably, such uncertainties only underscore the lack of parsimony associated with the whole convoluted inflationary string landscape scenario and also point to the need for an external source of design to cut the Gordian knot. Indeed, whenever we see systems exhibiting such causal circularity or interdependence and we know how they have arisen, invariably intelligent agency (usually engineers) played a role in the origin of such systems. Even so, other aspects of this fine tuning could not in principle result from a process that only shuffles initial conditions and does not also generate new laws of physics.

Note 16d.

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. In the mid-1990s, string theorists discovered that the five different "anomaly-free classes" of string theory exhibited mathematical equivalencies called dualities. These dualities implied the existence of a larger mathematical structure in which each of the five anomaly free classes of string theory—plus something called "11-dimensional supergravity"—could reside. Physicists call this mathematical structure "M-theory" where M stands for "mystery" or "membrane" or "mother of all theories."

In one of the most popular versions of M-theory, the "Cyclic Ekpyrotic Model," physicists Paul Steinhardt, Justin Khoury, Burt Ovrut and Neil Turok proposed that our universe, as well as many others, exists on (or in) a larger three-dimensional space called a "3-brane" (brane for a spatial "membrane"). In this picture of reality, the "3-brane" itself exists within a larger extra-dimensional space called "a bulk" that has eleven spacetime dimensions, six of which are compactified (and therefore unobservable) and the seventh of which separates the 3-brane on which our universe exists from another 3-brane. See Khoury et al., "The Ekpyrotic Universe: Colliding Branes and the Origin of the Hot Big Bang."

The Cyclic-Ekpyrotic model envisions these different 3-branes (each containing a collection of universes) colliding with each other once every trillion years or so. When such collisions occur, they generate new big bangs, that is, new universes. (*Ekpyrosis* means "conflagration" in ancient Greek). In fact, according to Steinhardt and colleagues, these periodic collisions between branes would produce enough energy to generate 10^{100} or even 10^{500} causally isolated universes, each with its own set of laws and constants and new initial conditions. Thus, these repeatedly colliding branes would eventually generate many separate universes with different laws *and* constants of physics, ultimately rendering our universe with its specific life-friendly laws and constants just another inevitable outcome of the "brane-to-brane" interactions of this proposed universe-generating mechanism.

This model does attempt to account for the fine tuning of both the laws and constants of physics *and* the initial conditions of the universe without invoking inflation. Even so, like the standard eternal inflation string multiverse hypothesis, the Cyclic-Ekpyrotic model multiplies theoretical entities and processes in a profligate manner to explain the fine tuning of our universe. These entities and processes include: (1) 3-branes, (2) multiple universes on each 3-brane, (3) an 11-dimensional space-time including seven unobservable spatial dimensions, (4) an 11-dimensional gravitational field operating in (5) "a bulk" containing parallel "3-branes" as well as (6) a process allegedly capable of generating new universes involving periodic collisions of the 3-branes themselves. In addition, this version of M-theory affirms the reality of many of the other theoretical entities present in more standard versions of string theory such as: (7)

vibrating (in this case) membranes of energy, (8) compactifications of space and (9) lines of flux. Clearly, the Cyclic-Ekpyrotic model does not represent a simpler or more economical explanation of the fine tuning than a theistic design hypothesis.

Note 16e.

Inflationary cosmology makes three key predictions, each of which have failed at least for the most prominent and empirically testable models. First, inflationary models typically predict larger variations in the temperature of the cosmic background radiation —beyond those produced by differences in mass-energy from the early universe. These increased variations result, in theory, from random local fluctuations in the inflaton field. Indeed, according to inflationary models, random quantum fluctuations in the field generate local differences in the energy density of space. Once the period of inflation ends, the energy of the inflaton field will be converted to ordinary mass-energy. Local differences in the density of mass-energy from previous fluctuations should, then, manifest themselves as larger variations (hot and cold spots) in the cosmic microwave background (CMB). Nevertheless, the new Plank satellite has harvested a massive amount of new data about the CMB and has failed to detect variations in the temperature of the radiation of the size expected by most inflationary models.

Second, the early inflationary models also predicted detectable gravity waves as a consequence of random local fluctuations in the gravitational field during the period of inflation. According to the initial versions of inflationary theory, the abrupt fluctuations in the gravitational field should produce "random warps in space" (changes in the curvature of spacetime). These abrupt changes or distortions in local curvature will then propagate as waves called "gravitational waves" through space as it expands. Upon interacting with photons, these waves will, according to theory, polarize in a distinctive and easily detectable pattern. Neither the Plank satellite, nor COBE satellite, has detected these polarization patterns, however. As Paul Steinhardt, one of the architects of inflationary cosmology who has since rejected it, explains, cosmologists "have not found any signs of the cosmic gravitational waves expected from inflation, as of this writing, despite painstaking searches for them." [Ijjas et al., "Pop goes the universe: The Latest Astrophysical Measurements, Combined with Theoretical Problems, Cast Doubt on the Long-Cherished Inflationary Theory of the Early Cosmos and Suggest We Need New Ideas," 37.]

Third, the initial versions of inflationary cosmology predict a phenomenon known as scale invariance in the imaging of the variations of the cosmic background radiation. Images are "scale invariant" if the scale at which the patterns in image are observed—how much the observer magnifies or "zooms" in on the image—doesn't affect how they look. Inflationary cosmology initially predicted moderate, but nothing close to perfect, scale invariance in the images depicting the variations in temperature in the cosmic background radiation. Instead, the recent Plank satellite data show *closer to perfect* scale invariance, much more so than expected by the most plausible inflationary models. Steinhardt comments on the significance of this and other recent failed predictions of the theory, "The Planck satellite results—[with their] . . . unexpectedly small (few percent) deviation from perfect scale invariance in the pattern of hot and colds spots in the CMB and the failure to detect cosmic gravitational waves—are stunning. For the first time in more than 30 years, the simplest inflationary models, including those described in standard textbooks, are strongly disfavored by observations. Of course, theorists rapidly rushed to patch the inflationary picture but at the cost of making arcane models of inflationary energy and revealing yet further problems."

Note 16f.

Oddly, the newer inflationary models suffer from the opposite problem as the earlier ones. Many of the evidences that they explain or predictions they make can be explained (or have been predicted) on the basis of other models. As Luke Barnes has noted: "inflation does provide some robust predictions, that is, predictions shared by a wide variety of inflationary potentials. The problem is that these predictions are not unique to inflation. Inflation predicts a Gaussian random field of density fluctuations, but thanks to the central limit theorem this is nothing particularly unique (Peacock, 1999, pg. 342, 503). Inflation predicts a nearly scale-invariant spectrum of fluctuations, but such a spectrum was proposed for independent reasons by Harrison (1970) and Zel'dovich (1972) [Harrison, "Fluctuations at the Threshold of Classical Cosmology," 2726–2730; Zel'dovich, "A hypothesis, unifying the structure and the entropy of the Universe," 7–8.] a decade before inflation was proposed. Inflation is a clever solution of the flatness and horizon problem, but could be rendered unnecessary by a quantum-gravity theory of initial conditions. The evidence for inflation is impressive but circumstantial [Barnes, "The Fine-Tuning of the Universe for Intelligent Life," 529–564; quote is on 540.].

In addition, there are so many different models of inflation that one inflationary model or another inevitably predicts nearly everything. For example, though proponents of inflation now claim the theory makes accurate predictions about, for example, variations in the Cosmic Background Radiation, critics have pointed out that earlier proponents of inflation made the opposite predictions prior to the publication of the Planck results. They argue this extreme flexibility renders inflation untestable.

See http://physics.princeton.edu/~cosmo/sciam/index.html#facts.

Chapter 17

Note 17a.

Einstein explained the photoelectric effect by postulating that light consisted of particle-like photons, rather than spatially-extended waves. Moreover, he argued that when these photons contained discrete packets of sufficient energy, they could bump electrons loose from an irradiated metal surface. Thus, Einstein concluded, in addition to its demonstrable wave-like properties, light also acted like a discrete particle or packet of radiant energy. As he explained: "In fact, it seems to me that the observations on black-body radiation, photoluminescence, the production of cathode rays by ultraviolet light and other phenomena involving the emission or conversion of light can be better understood on the assumption that the energy of light is distributed discontinuously in space. According to the assumption considered here, when a light ray starting from a point is propagated, the energy is not continuously distributed over an ever increasing volume, but it consists of a finite number of energy quanta, localized in space, which move without being divided and which can be absorbed or emitted only as a whole." (Einstein, "Über Einen Die Erzeugung Und Verwandlung Des Lichtes Betreffenden Heuristischen

Gesichtspunkt," 132–48.) The source is ter Haar's translation of Einstein's 1905 paper (first page of text):
https://vinaire.files.wordpress.com/2018/01/1905-paper-on-light-quanta-einstein1.pdf

Note 17b.

Though the observer-caused interpretation of the collapse of the wave function is now associated with the 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. Instead, he thought that quantum phenomena, including the collapse of the wave function, could be explained as the result of different experimental designs determining what human observers could observe of different facets of reality from different observational vantage points. In short, he thought that what we could observe was determined by the experimental setup in question. As the Stanford Encyclopedia of Philosophy notes, "Bohr flatly denied the ontological thesis that the subject has any direct impact on the outcome of a measurement…Rather, by referring to the subjective character of quantum phenomena he was expressing the epistemological thesis that all observations in physics are in fact context-dependent. There exists, according to Bohr, no view from nowhere in virtue of which quantum objects can be described. . .[A]lthough Bohr had spoken about "disturbing the phenomena by observation,"…he never had in mind the observer-induced collapse of the wave packet. Later, he always talked about the interaction between the object and the measurement apparatus which was taken to be completely objective.…What Bohr claimed was, however, that the state of the object and the state of the instrument are dynamically inseparable during the interaction. Moreover, the atomic object does not possess any state separate from the one it manifests at the end of the interaction because the measuring instrument establishes the necessary conditions under which it makes sense to use the state concept." See "https://plato.stanford.edu/entries/qm-copenhagen/; Halvorson, "Complementarity of Representations in Quantum Mechanics," 45–56. See also PBS Digital Studios, "The Quantum Experiment That Broke Reality."

Chapter 18

Note 18a.

A recently proposed competing theory of quantum gravity, known as loop quantum gravity (LQG), is also subject to the need to constrain degrees of mathematical freedom. Unlike theories of quantum cosmology, it does this in the process of modeling the current nature and structure of the universe rather that as part of an attempt to explain its origin.

One way to understand loop quantum gravity is by contrasting it with String Theory (see Chapter 16). In String Theory, the fundamental units of matter are thought to be vibrating strings of energy. Moreover, in string theory, the gravitational force results from gravitons, particles that carry (or exert) gravitational forces. Gravitons represent manifestations of quantized values of energy from underlying fields as described by quantum field theory. By contrast, Loop Quantum Gravity depicts fundamental physical reality not as particles or strings of energy, but as "lumps" of quantized space interconnected by "loops" of gravitational force. The limits on the geometry of the loops constrain the quanta of space to sizes on the order of the Planck length, which is about a billionth of a billionth of the diameter of a proton. The loops interconnect to form a 'spin network' that represents the fabric of space.

Since LQG describes quantized lumps of space interacting with each other as the result of gravitational forces, it represents a theory of quantum gravity. Consequently, it uses a version of the Wheeler-Dewitt equation to describe fundamental physical reality. The different solutions to the Wheeler-Dewitt equation are distinct interconnections of loops (spin networks) that define possible quantum states. In LQG, time is also quantized rather than continuous, so the Wheeler-Dewitt equation reduces to a difference equation that defines the discrete transitions between spin networks. This set of sequential spin networks comprises a "spinfoam," and the adding (superposition) of possible spinfoams describes the resulting spacetime. See Baggott, *Quantum Space: Loop Quantum Gravity and the Search for the Structure of Space, Time, and the Universe,* xii-xiii and Rovelli, "Loop Quantum Gravity," 5. Nevertheless, unlike the version of the Wheeler DeWitt equation used in "ordinary" quantum cosmology, the version in Loop Quantum Gravity uses a special set of variables derived from particle physics (i.e., from the standard model of particle physics and its subdiscipline quantum chromodynamics). This choice of variables results in different mathematical operators that the physicists apply to the **ψ** function term in the Wheeler De Witt equation. The choice of these variables, and the consequent operators, largely determine the solutions to the Wheeler DeWitt equation. The solution then describes an evolving "spin network" representing spin foams that provide the fundamental description of physical reality.

Loop quantum cosmology (LQC) applies LQG to the beginning of the expansion of the universe. In order to solve the Wheeler DeWitt equation LQG theorists make a number of simplifying assumptions. In particular, they assume that space is flat and homogeneous just as it is in our universe. They also assume (in many LQG models) that space is also isotropic and includes a massless scalar field.

The resulting solutions avoid a spatial singularity since the quantization of space limits the minimum spatial volume. Specifically, the spatial singularity in classical general relativity is transformed into a beginning point with spatial extent that bounces where a collapsing universe reaches a minimum size and then starts to expand. In addition, a generic feature of LQC is that space experiences a repulsive force during the bounce, so exponential inflation occurs without the need for the fine tuning of an inflaton field. See Date and Hossain, "Genericness of Inflation in Isotropic Loop Quantum Cosmology," 011301.

Though Loop Quantum Gravity theorists have also extended the theory to provide a cosmological model (thus, Loop Quantum Cosmology), LQC does not offer an explanation, and certainly not a completely materialistic explanation, for the origin of the universe. First, though LQC does eliminate a spatial singularity at the beginning of the universe (because, again, space is quantized, it never gets smaller than a distance related to the Planck length), it does not eliminate a temporal beginning to the universe. Indeed, the BGV theorem still applies to LQC, so the universe still had to have a beginning. See Mithani and Vilenkin, "Collapse of Simple Harmonic Universe," 028. In addition, in order to model the expansion of the universe accurately, Loop Quantum Gravity and Loop Quantum Cosmology requires, but does not explain, prior fine tuning. First, Loop Quantum Cosmology presupposes an extremely high degree of fine tuning for the entropy at the bounce or at some previous time. See Carroll, "Against a Bounce." Second, unlike string landscape cosmologies, LQC does not pose a vast ensemble of distinct universes with differing physical laws, so it does not even attempt to explain the fine tuning of the laws and constants of physics. Third, just to model the origin of the universe, LQC requires the input of external information (or fine tuning) to restrict possibility space—i.e., to limit mathematical degrees of freedom associated with the Wheeler-Dewitt equation. Indeed, in all such modelling, the physicists must constrain the possible solutions of the Wheeler-Dewitt equation by the special choice of variables, and by applying special assumptions about the nature of space, to ensure the resulting solutions describe physics that resembles that of our universe.

The physicist does this, first, not by the choice of restrictive boundary conditions as Vilenkin does in his model of quantum cosmology or by restricting the values of superspace as Hawking and Hartle (and Vilenkin) do in theirs, but instead by the choice of the variables that determine the mathematical operators that in turn determine the solution to the Wheeler DeWitt equation. The choice of these operators drastically restricts the space of possible universes. Moreover, like other quantum cosmological models, LQC theorists further restrict possible solutions of the Wheeler DeWitt equation by making simplifying assumptions about the geometry of space—in particular, the assumptions that space is homogeneous and flat and (in some models) that it is isotropic and contains a massless scalar field. These assumptions ensure that the resulting solution describes a universe with physics like our own

Consequently, these models do not explain how, for example, homogeneity or flatness arose without fine tuning. Instead, the assumption of homogeneity and flatness is built into the models and derives in the models from the choice—the fine tuning—of the theorists themselves. Similarly, theoretical physicists themselves choose the variables (and, consequently, the mathematical operators) used to solve the Wheeler DeWitt equation, and they do so in such a way as to allow for solutions that model our universe. Of course, there is nothing illicit in trying to model the universe as it is. It is important to recognize, however, that LQC does not explain the *origin of* the universe or its fine tuning. Indeed, if anything, it models the need for an intelligent input of information into the Wheeler DeWitt equation, implying that the universe as described by LQC is also fine tuned. Indeed, the assumptions about space built into the Wheeler DeWitt equation and the choices of the mathematical operators needed to solve it, are essentially reverse engineered to produce a solution that describes a universe with a particular physics resembling our own. This represents a perfectly legitimate attempt to model the universe; it does not in any way explain how it originated without external fine tuning. The LQC model, like other quantum cosmologies, requires the input of external information in the form of constraints on mathematical degrees of freedom. In addition, the BGV theorem still applies to LQC, so the universe still had to have a beginning.

Chapter 20

Note 20a.

Tyson continued at great length in his *Cosmos* program to indict Newton for his fallacious reasoning. Tyson's badly misinformed history of science is on display in this extended excerpt from the transcript to his 2010 lecture critiquing the idea intelligent design. Notice that Tyson asserts, among many other errors, that Newton thought that the solar system was unstable. Here is a lengthy quote from his lecture: "He didn't mention God talking about his formula F=ma, his formula for motion. He didn't talk about God when he knew and figured out the motions of the planets, his universal law of gravity. God is nowhere to be found. He gets to a point where he can't answer the question. God is there. That's intelligent design. Something he couldn't figure out…He didn't say maybe someone else smarter than I am will figure this out one day. It's not what he said. And so, this concept of reaching the limits of your knowledge and then saying, God is there, is old! It's not new. It didn't first show up in Dover, Pennsylvania."

Tyson continued: "So, now what happened? Let's fast forward. It took a hundred and thirty years, but someone was finally born who could solve that problem. Simon Pierre de Laplace, a brilliant mathematician, of the late eighteenth century. In the last three years of the eighteenth century, he produced a five-volume tome, called *C'eleste Mechanique*. So in there, he studies the stability of the solar system, perfects a new branch of calculus called perturbation theory, and what he says is, ok, I can figure it out. Set up the equation this way. You've got the main force, and then you have these little tugs. Represent all these little tugs by this term and this equation. Now crank the equation. And when you do that, it turns out the little tugs don't amount to much. They all cancel out. And so then, in fact, the solar system is stable, beyond Newton's projections for it.

Napoleon, who's a contemporary of Laplace, summed up this document. . . So he summons up Laplace, said this is a brilliant piece of work. Napoleon was smart enough to have read this book. Knew enough math to have read this book, got the gist of it. He said, Laplace, this is a brilliant piece of work, but you make no mention of the architect of the system. And Laplace replied, "Sir, I have no for that hypothesis." And so here you have a delay of 130 years of a problem that previously was ascribed to the handiwork of God, now was no longer an assumption. And it gets solved by somebody who is brilliant. And so what we've learned over all of these examples, and there are tons of them that one can cite, is that intelligent design is a philosophy of ignorance. It is you get to something that you don't understand, and then you stop. You say God did it. And you no longer progress beyond that point." See the audio lecture: "Neil deGrasse Tyson on Intelligent Design" at: https://youtu.be/EQucyuKsrOE

Note 20b.

He 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: "We are to admit no more causes of natural things than such as are both true and sufficient to explain their appearances." Newton, *Mathematical Principles of Natural Philosophy*, 398.

Consistent with his own rules of reasoning, Newton did not assert or infer God's action just because of the inadequacy of explanations that relied on what he called "brute matter." Instead, he posited the design of "an intelligent and powerful being" because of evidence from the natural world that seemed to him to require a cause with attributes that intelligent agents are known to possess. In the case of the solar system, the *irregular, but highly specific* positioning of the planets and comets around the Sun as a condition of the stability of the system suggested an intelligent cause to him, doubtless because he had observed intelligent agents specifically configuring material components in highly irregular ways in order to achieve discernable purposeful outcomes. Similarly, since complex organs of sense such as the eye exhibit a complex integration of parts to achieve a discernable functional end, that too suggested an intelligent cause or what he called "the effects of Choice," rather than chance or "the mere Laws of Nature." Newton, *Opticks: Or, a Treatise of the Reflections, Refractions, Inflections and Colours of Light,* 2 ed. In the case of gravitation, he thought that its universality suggested an omnipresent cause. He also thought that the absence of direct material interaction —the phenomenon of action at a distance—suggested the need for a cause that was not itself material but could instantaneously affect material bodies. Since God as conceived by theists possesses precisely those attributes he, albeit privately, expressed support for the causal adequacy of the God hypothesis and as an explanation for action at a distance. Consequently, he saw in nature positive evidence for the past acts and on-going action of God.

Note 20c.

Snobelen points out that Newton had a providential and dynamic view of the cosmos that paralleled his interpretation of biblical eschatology. Thus, in addition to positing God's constant sustaining power and his past acts of creation, Newton anticipated, based upon his understanding of scripture, that the physical cosmos would run down over time, thus eventually requiring "reformation." (See endnote 30, Chapter 20). Though he primarily saw that reformation coming at the end of time as part of God's "recreation of a new heavens and a new earth" Snobelen thinks, based in part on an interview that Newton gave late in his life with his nephew-in-law John Conduitt, that he may have also thought that God made provision for periodic reformations before then as well. [Kubrin, "Newton and the Cyclical Cosmos: Providence and the Mechanical Philosophy." 325–46, esp. 340–43. Conduitt, "Account of a conversation between Newton and Conduitt."] Nevertheless, Newton seems to have envisioned those reformations coming through the *preordained* secondary agency of comets. In particular, he seems to have thought that comets would eventually fall from their orbits into the sun and provide energy to "replenish the sun." As Snobelen notes, "A dominant theme in Newton's prophetic writings is that of apostasy and reformation, that is, the tendency for religion to become debased and ineffective over time, which in turn requires the intervention of God to restore religion to its ideal state through the witness of prophets. In his cosmology, Newton likewise came to believe that the accumulation of irregularities in the planetary system could be corrected through such physical agencies as comets." [Snobelen. "Cosmos and Apocalypse: Prophetic Themes in Newton's Astronomical Physics"; See also Snobelen, "Cosmos and Apocalypse," 76–94.].

Modern readers might be tempted to regard this as a genuine example of a God-of-the-gaps argument in Newton's scientific corpus. But several considerations weigh against this interpretation. First, Newton never published this idea in any of his scientific works, and when asked why he didn't in the interview near the end of his life, he replied "I do not deal in conjectures." [Conduitt, "Account of a conversation between Newton and Conduitt."] Second, according to those who worry about making GOTG arguments, it's important to remember this fallacy allegedly occurs when a scientist posits God's direct action to fill a gap in our knowledge of the natural causes of an *apparent* discontinuity in nature, thus foreclosing the possibility of any further scientific investigation. (Of course, this worry begs the question as explained above. GOTG objectors assume discontinuities in nature are only apparent and not real because they also assume that creative intelligence did not cause any such discontinuity—i.e., they assume naturalistic explanations will suffice to account *for everything*). Even so, in the case of Newton's private and unpublished conjecture concerning comets reforming the solar system—arguably the best example that proponents of the GOTG story can possibly muster from the historical record—Newton doesn't posit God as an explanation for an apparent causal discontinuity in nature—that is, he doesn't make a GOTG argument. Instead, Newton merely speculates that a preordained scientifically-explicable secondary agency might be responsible for reforming and thus *maintaining* the continuity of the solar system. He does not posit direct divine intervention, but instead a secondary *natural* cause (albeit one preordained by God). He does not posit direct divine intervention to fill a gap in our knowledge of the causes of a discontinuity in nature, since no such discontinuity in the solar system has yet emerged and, in any case, the instability (discontinuity) that he anticipates later arising will emerge as the result of the *natural* tendency for complex systems to run down. Nor, finally, does his speculation foreclose scientific investigation, since he anticipates that the cause of the replenishing of the Sun and solar system will be the orbital decay of comets, a natural phenomenon subject to human observation and mathematical description. Clearly, Newton had a profound, complex and nuanced view of how God interacts with nature, but his view did not lead him to make GOTG arguments, nor did it inhibit either his investigation of how nature operates or his consideration of how it might have originated.

Chapter 21

Note 21a.

The pervasiveness of religious belief worldwide [as opposed to the growing secularism among college-educated millennials] highlights a deep problem for a strictly naturalistic and evolutionary account of the origin of our cognitive equipment. Multiple studies across many populations indicate that human beings are hardwired for religious belief. [See: Justin Barrett, *Cognitive Science, Religion, and Theology* (West Conshohocken, PA: Templeton Press, 2011); Justin Barrett, *Born Believers: The Science of Childhood Religion* (New York: Free Press, 2012); see also Oxford University's press release, "Humans 'Predisposed' to Believe in Gods and the Afterlife," 16 May 2011, available at: https://phys.org/news/2011-05-humans-predisposed-gods-afterlife.html. Deborah Kelemen, Joshua Rottman, and Rebecca Seston, "Professional Physical Scientists Display Tenacious Teleological Tendencies: Purpose-Based Reasoning as a Cognitive Default," *Journal of Experimental Psychology: General*, 15 October 2012, advance online publication: doi: 10.1037/a0030399. Art Jahnke, "The Natural Design Default," *Bostonia* (Winter-Spring 2013): 22–23, esp. 23.]

Acceptance of the supernatural appears to be deeply built into the foundations of our cognition, evident even among young children. As Berkeley psychology professor Alison Gopnik observes, "By elementary-school age, children start to invoke an ultimate God-like designer to explain the complexity of the world around them—even children brought up as atheists." [Alison Gopnik, "See Jane Evolve: Picture Books Explain Darwin," *Wall Street Journal*, 18 April 2014, available: http://www.bu.edu/cdl/files/2014/04/WSJ-Teaching-Tots-Evolution-via-Picture-Books-WSJ.com_.pdf. See also Rebekah A. Richert and Justin L. Barrett, "Do You See What I See? Young Children's Assumptions about God's Perceptual Abilities," *The International Journal for the Psychology of Religion*, vol. 15, no 4 (2005): 283–95. Deborah Kelemen et al., "Young Children can be Taught Basic Natural Selection Using a Picture-Storybook Intervention," *Psychological Science*, vol. 25, no. 4 (2014): 894.]

In addition, the Pew Research model projects that over the next three decades, as a percentage of the total population of the world, religiously affiliated populations will likely increase in comparison to religiously unaffiliated populations. The Pew survey projects this increase mainly due to higher birthrates among religiously affiliated, as opposed to, unaffiliated populations. [https://www.pewforum.org/2017/04/05/the-changing-global-religious-landscape/. Accessed 9 August 2019; Conrad Hackett et al., "The Future Size of Religiously Affiliated and Unaffiliated Populations." https://www.pewforum.org/2017/04/05/the-changing-global-religious-landscape/. Accessed 9 August 2019.

See also: https://www.pewforum.org/2015/04/02/religious-projections-2010-2050/. Accessed 9 August 2019.] As Conrad Hackett and colleagues make clear, "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." (Page 830). Evidently, religious belief correlates with higher rates of reproductive success, precisely what the evolutionary process favors. But that means the evolutionary process seems to select or favor human populations with false beliefs—at least, as defined by evolutionary naturalists.

Note 21b.

Here's how Plantinga expresses his overall argument in brief form: "The basic idea of my argument could be put (a bit crudely) as follows. First, the probability of our cognitive faculties being reliable, given naturalism and evolution, is low. (To put it a bit inaccurately but suggestively, if naturalism and evolution were both true, our cognitive faculties would very likely not be reliable.) But then according to the second premise of my argument, if I believe both naturalism and evolution, I have a *defeater* for my intuitive assumption that my cognitive faculties are reliable. If I have a defeater for *that* belief, however, then I have a defeater for *any* belief I take to be produced by my cognitive faculties." Alvin Plantinga, *Where the Conflict Really Lies: Science, Religion, and Naturalism* (Oxford: Oxford University Press, 2011), 314, original emphases. Of course, if an evolutionary naturalist has a defeater for *any* belief that he takes to be produced by his cognitive faculties, then he has a defeater for his beliefs that "evolution is true," "naturalism is true," and "my mind is reliable." Epistemologically speaking, his evolutionary naturalism destroys itself. Having noted this implication, I draw attention to the fact that *my* argument in this chapter is not that evolutionary naturalism is self-defeating per se, but rather that given the conjunction of evolution and naturalism, there is a low probability that our cognitive faculties are reliable, including those cognitive faculties necessary for science.