



· Chapter 6 ·

The Myth of the Clockwork Universe

Newton, Newtonianism, and the Enlightenment

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[The Lord God] is eternal and infinite, omnipotent and omniscient, that is, he endures from eternity to eternity, and he is present from infinity to infinity; he rules all things, and he knows all things that happen or can happen.

—Isaac Newton, General Scholium
to the *Principia* (1726)

The myth of Newton's clockwork universe is one of the most persistent and pervasive myths in the history of science, perhaps almost as widespread as the mistaken and essentialistic belief that the Galileo Affair involved some sort of clash between "science" and religion (even though one of the main dynamics was a clash between two forms of science). Like the popular conception of Galileo's troubles with the hierarchy of the Catholic Church, the myth of Newton's clockwork universe is recognized as a myth by most informed historians of science but not by the wider public. The myth of the clockwork universe as applied to Newton has several components, not all of which are always present in any given articulation of it. These include the idea



that the universe is like a machine or clockwork mechanism; that God created the cosmos and set it in motion but now no longer intervenes in it or governs it; that the cosmos follows deterministic laws; that Newton was a deist or protodeist; and that Newton through his physics either unwillingly or even willingly excluded God from the universe.

Examples of the myth abound. In an agenda-driven article commemorating the 150th anniversary of Darwin's theory, Johnjoe McFadden blithely states that two hundred years before Darwin "Newton had banished God from the clockwork heavens."¹ On this sort of reading, Newton is part of a metanarrative about the secularizing influence of science through the ages.² In an extra feature of "Beyond the Big Bang," the final episode for the 2007 season of the History Channel series *The Universe*, respected physicist Michio Kaku says: "Newton believed that the universe was a clock. A gigantic clock—a machine—that God wound up at the beginning of time, and it's been ticking ever since due to his laws of motion."³ Science writer Edward Dolnick's 2011 book *The Clockwork Universe: Isaac Newton, the Royal Society and the Birth of the Modern World* will help keep the myth alive.⁴ This is no straw man. The myth of the clockwork universe is both common and for many seemingly assumed. Regrettably, while the scholarly community has begun to outgrow this myth, it had a hand in perpetuating it, especially during the first half of the twentieth century.⁵

The situation changed dramatically in the second half of the twentieth century, although not all at once. The single most important development was the sale of Newton's nonscientific papers at Sotheby's in London in 1936. A large number of the theological and alchemical papers were purchased by the economist John Maynard Keynes, who left them to King's College, Cambridge, at his death in 1946; selections from the theological portion were published in 1950 by Herbert McLachlan. A second large collection of Newton's theological and alchemical papers, assembled by the Jewish Orientalist A. S. Yahuda, arrived at the Jewish National and University Library in Jerusalem in the late 1960s and subsequently became accessible to researchers. Even wider access began in 1991 with the release of the majority of Newton's manuscripts. The next stage came with the founding of the Newton Project in 1998, which soon after began to mount professional

transcriptions of the papers on the Internet. Partway through this decades-long process of manuscript revelations came a new historiographical mood among Newton scholars, who now had increasing access to Newton's massive manuscript corpus. One outcome was a greater tendency among scholars, secular or otherwise, to argue for the importance of Newton's religion to his science.⁶

The purpose of this essay is to demonstrate the conceptual distance between Newton's actual worldview and the metaphor of the secularizing clockwork universe by drawing on the wealth of resources in Newton's published works and his massive manuscript corpus. The essay consists of two parts. In the first part I show that a deistic clockwork view of the world contrasts with an authentic and accurate presentation of Newton's theology and providentialist physics. The second part looks at the interpretations of Newton's theology and physics offered by Newton's early disciples. I show that Newton's closest followers reassert the central features of his theological conception of the world, including the role of suprimechanical forces, the reality of processes of degeneration in the cosmos, the true rather than nominal omnipresence of God, and the rejection of mere mechanism and the God-banishing clockwork universe. I conclude with a brief postscript on Newton and his secularization in the European Enlightenment.

Providential Themes in Newton's Cosmology

The first step in undoing the clockwork myth is to correct the notion that a clockwork view of the cosmos is necessarily secular or ultimately born out of deism. It was not during the Renaissance or Scientific Revolution that the clockwork metaphor was born,⁷ but centuries before among pious medieval monks. The clockwork analogy of the universe—popular conceptions of its association with deism and materialism notwithstanding—is tied to the medieval conception of the cosmos as an assembly of nested and regularly moving crystalline spheres. The expression *machina mundi* (“world machine” or “machine of the universe”) was employed in works on astronomy in the late medieval period by Robert Grosseteste (ca. 1175–1253),

Johannes de Sacrobosco (fl. 1230), and Nicholas of Cusa (1401–64).⁸ It appears in Nicholas Copernicus's *De revolutionibus* (1543) as well.⁹ Nicole Oresme (ca. 1325–82) took the step from the term *machina mundi* to a universe-clockwork comparison.¹⁰ Comparisons of God with a clockmaker are used by the archbishop of Canterbury, Thomas Bradwardine (ca. 1290–1349), as well as Henry of Langenstein (d. 1397).¹¹ The clockwork analogy is also used in medieval literary contexts by the French poets Jean Froissart (1333?–1400/1) and Christine de Pisan (1364–ca. 1430) and the great Florentine poet Dante Alighieri (ca. 1265–1321).¹² In these early theological contexts, the clockwork analogy has two essential features: God as creator of the clockwork and God as sustainer of the clockwork. Thus it differs from eighteenth-century, nonprovidentialist deism that is committed only to the first element.¹³

While the accompanying philosophy and theology change in the seventeenth century, the theologically positive use of the clockwork analogy does not. This can be seen among three leading advocates of the mechanical philosophy, all French Catholics: the friar Marin Mersenne, the priest Pierre Gassendi, and the Jesuit-educated René Descartes. Mersenne contends for a clockwork analogy of the universe, convinced that the mechanical philosophy can serve as a defense of theistic belief.¹⁴ Gassendi, famous for reviving and Christianizing Epicurean atomism, compares the wisdom evident in creation with the intentionally designed clock.¹⁵ As for Descartes, while not advocating a cogged machine *per se*, he does describe the world as a machine and is fond of describing animals as clocks and humans as clocks with souls.¹⁶ The Protestant advocates of the mechanical philosophy Johannes Kepler and Robert Boyle also employ the clockwork analogy.¹⁷ Kepler speaks of his efforts to understand the physical causes of the planetary system in clockwork terms;¹⁸ Robert Boyle uses the clockwork metaphor to argue for both divine transcendence and the radical contingency of creation.¹⁹ Whatever the uses of the clockwork metaphor in later Enlightenment and post-Enlightenment thought, the clockwork view of the universe was seen by these Christian thinkers as a friend of Christianity and a powerful defense against atheism.²⁰



In this light, advocacy of the clockwork metaphor prior to the publication of Newton's *Principia* need not imply some kind of protodeistic conception of the world. The early advocates of the clockwork universe were pious, believing Christians. Had Newton advocated the clockwork metaphor, he would have joined the ranks of those Christian natural philosophers who went before him. Did Newton adopt this metaphor? Although examples abound of people declaring, after Newton's time, that Newton espoused a clockwork universe, quotations from his writings that specifically support this assertion are never proffered. There is a good reason for this. To date, not a single example of Newton unambiguously referring to the universe as a clockwork system has surfaced. Given that others in his own day and before did use this analogy (including Boyle, with whom Newton was personally acquainted), and given the voluminous nature of his published and unpublished writings, his omission of it is all the more striking.

In this section, I will show that, contrary to common conceptions that he held to a semideistic, clockwork model of the universe, Newton had a providentialist view of the cosmos that was informed by a belief in an omnipresent and omniscient God continuously in control of his creation. The evidence brought forward to demonstrate these elements of Newton's thought will also show that this pioneer of modern physics cannot be classified with strict accuracy as a mechanist. Newton's status as an active lay theologian is now well established in Newton scholarship, so there is no need to go over this now well-trodden ground here. The question that concerns us here is the degree to which Newton's theological beliefs informed or infused his cosmology.²¹

A useful place to start is Newton's most well-known book, the *Principia mathematica*. Although there is a misconception that the first edition of 1687—unlike the second and third editions of 1713 and 1726—was published bereft of theological language, this is in fact not the case.²² It is true, however, that the first edition is *almost* bereft of theological language. When the *Principia* was first published, it contained only one reference to the Bible and one to God. The reference to the Scriptures occurs near the beginning of the book in the Scholium



on the Definitions. Here Newton says that it is just as important to distinguish between absolute and relative language in the Bible as it is to distinguish between absolute and relative senses of time, space, place, and motion in physics.²³ The reference to God occurs in book 3, proposition 8, corollary 5, where Newton discusses the felicitous arrangement of the planets around the sun—including the earth’s location in a position that allows the existence of liquid water. He concludes this discussion by stating: “Therefore God placed the planets at different distances from the sun so that each one might, according to the degree of its density, enjoy a greater or smaller amount of heat from the sun.”²⁴ In 1713, Newton removed the word *God* from this passage and replaced it with a passive verbal construction in a reworked section of what would become corollary 4. Nevertheless, the revised material is a palimpsest that not only continues to articulate an argument from design based on the arrangement of the solar system but in its reworked form arguably presents a *more* powerful case for design by virtue of being more intuitive and less weighed down with mathematical detail.²⁵

But even in the first edition, there is more material of theological significance than meets the eye. Thus Newton’s discussion of the absolute and the relative in the Scriptures as part of an argument about the absolute and the relative in physics suggests a structural relationship between Newton’s biblical hermeneutics and his study of the cosmos. The drafts of this material show that Newton had more theological ideas when writing this portion of the *Principia* than he allowed to appear in print.²⁶ Also, we now know that Newton’s discussion of absolute time and space in the Scholium on the Definitions emanates in part from his theological notions of God’s eternal duration and omnipresence. Newton’s comment about God’s placement of the stars is additionally connected with his providentialist understanding of the creation of the cosmos. All of this takes on added significance in light of Newton’s manuscript “De gravitatione”—likely composed shortly before he began work on the *Principia*—which not only attacks the deficiencies of the Cartesian cosmology but also speaks about God’s omnipresence and action in the world and argues that the notion of matter existing independently of God offers a path to atheism.²⁷



The first edition of the *Principia* also needs to be seen in the light of two sets of documents he produced shortly after its publication: his correspondence with Richard Bentley in 1692–93 and his Classical Scholia, drafted around the same time. Bentley sought Newton's aid in late 1692 when writing up his Boyle Lectures for publication.²⁸ He intended to enlist the new physics of the *Principia* in support of the design argument and hence the existence of God. The words with which Newton began the first of his four letters to Bentley are now famous: "When I wrote my treatise about our system, I had an eye upon such principles as might work with considering men, for the belief of a deity, and nothing can rejoice me more than to find it useful for that purpose."²⁹ The arguments for design that Newton presents in his letters to Bentley focus on the providential arrangement of the structure of the solar system and God's continuous upholding of this system in some way through gravitation. With respect to the first dynamic, Newton stresses in his first letter that the complex arrangement of the planetary system points to a cause that is "not blind and fortuitous, but very well skilled in mechanics and geometry."³⁰ In his second letter, he contends that the force of gravity on its own would not have been sufficient to create the motions of the planets: "So then gravity may put the planets into motion, but without the divine power it could never put them into such a circulating motion as they have about the sun; and therefore, for this, as well as other reasons, I am compelled to ascribe the frame of this system to an intelligent agent."³¹ In his fourth letter Newton strongly rejects as an "absurdity" the idea that gravity is innate in matter and that it can operate across distances without the mediation of something else. He writes: "Gravity must be caused by an agent acting constantly according to certain laws; but whether this agent be material or immaterial, I have left to the consideration of my readers."³² Bentley proved to be a quick study, and in the published version of his Boyle Lectures he expands on Newton's hints, declaring gravitation to be a supramechanical force that "proceeds from a higher principle, a Divine energy and impression."³³

Newton himself crafted even bolder statements in his Classical Scholia, a set of scholia written in the early 1690s for a second edition of the *Principia* that he was planning. These additions were meant to



show the continuity between the wisdom of the ancients and Newton's physics, including his understanding of gravitation and the inverse-square law. But the Classical Scholia also include discussions of God's omnipresence and activity in the world. The following passage from this collection is an example:

That God is an entity in the highest degree perfect, all agree. But the highest idea of the perfection of an entity is that it should be one substance, simple, indivisible, living and life-giving, always everywhere of necessity existing, in the highest degree understanding all things, freely willing good things; by his will effecting things possible; communicating as far as is possible his own similitude to the more noble effects; containing all things in himself as their principle and location; decreeing and ruling all things by means of his substantial presence . . . ; and constantly co-operating with all things according to accurate laws, as being the foundation and cause of the whole of nature, except where it is good to act otherwise.³⁴

Along similar lines, a new corollary to proposition 9 in book 3 of the *Principia* reads: "There exists an infinite and omnipresent spirit in which matter is moved according to mathematical laws."³⁵ And in another place, Newton records, in similar terms, what he believes the ancients thought about gravity: "Quite apparently [they thought] the heavens are nearly free of bodies, but nevertheless filled everywhere with a certain infinite *spiritus*, which they called God."³⁶ It seems likely that some of Newton's thinking about the universal spirit in the cosmos (which is ultimately linked to God's omnipresence) was shaped by his study of and practice of alchemy, which also posits a nonmechanical, active spirit in the world.³⁷

Newton's own mature views were published in the two versions of the General Scholium to the *Principia*.³⁸ The General Scholium, a sort of general-purpose appendix, first appeared with the second edition of the *Principia* in 1713. An amended and elaborated version appeared in the third edition of 1726. The beginning of the General Scholium is devoted to comments on the complex motions of the planets and



comets in the solar system. This discussion leads naturally for Newton to a consideration of the designer of this system—a system whose operations it was Newton’s honor to explain through a detailed mathematical description for the first time in his *Principia*. Newton expostulates: “This most elegant system of the sun, planets, and comets could not have arisen without the design and dominion of an intelligent and powerful being.”³⁹ Here, in a memorable line, are identified Newton’s two essential theological roles of God in the cosmos: God as creator *and* sustainer of the heavens and earth. Newton’s God has complete dominion not merely in word but in actuality: “He rules all things, not as the world soul but as the lord of all. And because of his dominion he is called Lord God *Pantokrator*.”⁴⁰ God’s sovereignty is truly universal, and his rule is that of a personal God, not the vague, impersonal *anima mundi* of Greek philosophical schools, such as the Stoics. Instead, Newton’s view of God’s sovereignty can be compared with that of John Calvin, who declared: “We mean by providence not an idle observation by God in heaven of what goes on in earth, but His rule of the world which He made; for He is not the creator of a moment, but the perpetual governor.”⁴¹ Newton also distances his thought from pantheism, by explicitly denying that God’s dominion involves dominion over the world as over his body, such as is the case with the world soul.⁴² By speaking of classic Jewish and Christian notions of God’s sovereignty and deploying biblical names and titles of the deity, Newton was making his theological affiliations clear.

Newton offers further detail on God’s omnipresence and universal dominion later in the General Scholium. In elaborating on God’s omnipresence, he writes: “He is eternal and infinite, omnipotent and omniscient, that is, he endures from eternity to eternity, and he is present from infinity to infinity; he rules all things, and he knows all things that happen or can happen. He is not eternity and infinity, but eternal and infinite; he is not duration and space, but he endures always and is present everywhere, and by existing always and everywhere he constitutes duration and space.”⁴³

For Newton, the nature of God’s omnipresence involves his literal presence everywhere at all times: “He is omnipresent not only *virtually* but also *substantially*; for action requires substance. . . . In him all



things are contained and move, but he does not act on them nor they on him. God experiences nothing from the motions of bodies; the bodies feel no resistance from God's omnipresence."⁴⁴ To the quotation from Acts 17:28 ("In him all things are contained and move"), Newton adds his footnote on space. This note contains a series of references to classical authors who offer analogies to the notion of a ubiquitous spirit, along with Philo Judaeus and a *florilegium* of quotations about God's omnipresence from the Bible.⁴⁵ After further discussions of God and his attributes, Newton moves on to consider gravity, for which he refuses to assign a cause: "I do not feign hypotheses" (*Hypotheses non fingo*), he says.⁴⁶ The placement of a consideration of universal gravitation immediately after a discussion of God that includes statements about his omnipresence, however, may have been intended to suggest that it was God who was behind this power. After all, for Newton, only two things are truly universal in the spatial sense: gravity and God's omnipresence.

The General Scholium offers another important insight into Newton's understanding of God's activity in the world. In a comment on the distribution of the fixed stars, which was added to the third edition shortly after his bold declaration of the "most elegant system of sun, planets, and comets," Newton states: "And so that the systems of the fixed stars will not fall upon one another as a result of their gravity, he has placed them at immense distances from one another."⁴⁷ Here Newton speaks of an element of his system that is rarely discussed: gravity can be a *destabilizing* force just as it can be a *stabilizing* force. When we recognize that gravity can be both for Newton, we see the significance of his careful comments about God placing the stars at appropriate distances from each other. But Newton contemplated an even stronger statement for this place in the third edition. In an annotation to his copy of the second edition, Newton wrote: "et fixarum systemata per gravitatem suam in se mutuo paulatim caderent nisi omni consilio Entis summi regerentur," that is, "and the fixed stars would, through their gravity, gradually fall on each other, were they not carried back by the counsel of the supreme Being."⁴⁸ Once more, God is essential to the ongoing stability of the system.

Newton's *Opticks* (first published in English in 1704) provides further examples of Newton's dynamic cosmos.⁴⁹ When Newton had



the *Opticks* translated into Latin in 1706 by his supporter Samuel Clarke, he used the opportunity to add seven new and elaborative queries to the original sixteen concise queries. These appeared with some amendments in the second English edition of 1717. The two queries that interest us are those eventually numbered 28 and 31. In a place in query 28, where he rejects an ether-filled plenum and notes the ancient belief in a vacuum, Newton writes that “the main Business of Natural Philosophy is to argue from Phænomena without feigning Hypotheses, and to deduce Causes from Effects, till we come to the very first Cause, which certainly is not mechanical.”⁵⁰ This cause, for Newton, is God—not the closed, self-contained, and thoroughly mechanical system of some later French thinkers.

Further on, in query 31, Newton considers both the power of gravity in the heavens and the active powers that operate between the smallest particles. He writes:

And thus Nature will be very conformable to her self and very simple, performing all the great Motions of the heavenly Bodies by the Attraction of Gravity which intercedes those Bodies, and almost all the small ones of their Particles by some other attractive and repelling Powers which intercede the Particles. The *Vis inertiae* is a passive Principle by which Bodies persist in their Motion or Rest, receive Motion in proportion to the Force impressing it, and resist as much as they are resisted. By this Principle alone there never could have been any Motion in the World. Some other Principles was necessary for putting Bodies into Motion; and now they are in Motion, some other Principle is necessary for conserving the Motion.⁵¹

Once again we see (indirectly, in this case) Newton’s two roles for God in the universe at work: creating and sustaining. Newton adds to this a remark about the tendency for motion to decrease over time: “By reason of the Tenacity of Fluids, and Attrition of their Parts, and the Weakness and Elasticity in Solids, Motion is much more apt to be lost than got, and is always upon the Decay.”

Query 31 also provides an elaborate and colorful description of active principles at work in the world:



Seeing therefore the variety of Motion which we find in the World is always decreasing, there is a necessity of conserving and recruiting it by active Principles, such as are the cause of Gravity, by which Planets and Comets keep their Motions in their Orbs, and Bodies acquire great Motion in falling; and the cause of Fermentation, by which the Heart and Blood of Animals are kept in perpetual Motion and Heat; the inward Parts of the Earth are constantly warm'd, and in some places grow very hot; Bodies burn and shine, Mountains take Fire, the Caverns of the Earth are blown up, and the Sun continues violently hot and lucid, and warms all things by his Light. For we meet with very little Motion in the World, besides what is owing to these active Principles. And if it were not for these Principles the Bodies of the Earth, Planets, Comets, Sun, and all things in them would grow cold and freeze, and become inactive Masses; and all Putrefaction, Generation, Vegetation and Life would cease, and the Planets and Comets would not remain in their Orbs.⁵²

This is not a world whose motion is merely dependant on an initial divine push. It is a dynamic world in which decline is mixed with renewal.

Three pages later Newton explicitly mentions the gradual buildup of irregularities in the solar system that bring about the need for a correction: "For while Comets move in very excentrick Orbs in all manner of Positions, blind Fate could never make all the Planets move one and the same way in Orbs concentrick, some inconsiderable Irregularities excepted which may have risen from the mutual Actions of Comets and Planets upon one another, and which will be apt to increase, till this System wants a Reformation. Such a wonderful Uniformity in the Planetary System must be allowed the Effect of Choice."⁵³ This, evidently, is the statement that provoked Leibniz to claim that Newton's God was a clockmaker without sufficient foresight to make the world a perpetual-motion machine. Thus Newton's providentialist cosmology was not merely a part of his private faith: it appears in both the *Principia* (including the first edition) and the *Opticks*.

Newton's use of such a religiously charged term as *reformation* and the implication that this "reformation" would be effected by God leads



us to Newton's unpublished theological manuscripts. Anyone who is familiar with the hundreds of thousands of words Newton wrote on Daniel and the Apocalypse, along with other biblical prophecies, will know that he spent a good part of his life living in the world of prophecy, both fulfilled and unfulfilled. Newton also held to a pre-millennial eschatology, believing that Christ would one day return to set up the Kingdom of God on earth. One of the central themes of Newton's prophetic writings is the cycle of apostasy and reformation in salvation history. Newton believed that the Jews had corrupted their religion by the time of Christ and that the Christians had corrupted theirs in the centuries following the first advent of Christ. The chief problem was lapsing into idolatry. It happened to ancient Israel and it happened to Christianity (especially the Roman Church), although God always preserved a faithful remnant. But, in biblical times at least, God had sent reformers to lead his people back to the true faith.

Newton outlines this pattern in his "Irenicum," a theological manuscript that dates to the early eighteenth century. In speaking about the Two Greatest Commandments (loving God and loving neighbor), he asserts:

These two commandments always have and always will be the duty of all nations and The coming of Jesus Christ has made no alteration in them. For as often as mankind has swerved from them God has made a reformation. When the sons of Adam erred and the thoughts of their heart became evil continually God selected Noah to people a new world and when the posterity of Noah transgressed and began to invoke dead men God selected Abraham and his posterity and when they transgressed in Egypt God reformed them by Moses and when they relapsed to idolatry and immorality God sent Prophets to reform them and punished them by the Babylonian captivity.⁵⁴

But it did not end with the Babylonian Captivity. When the exiles returned, the Jews once again became corrupted by mixing "human inventions with the law of Moses under the name of traditions" and thus "God sent Christ to reform them." When they rejected Christ,



“God called the Gentiles.” But the Christians were no better than the Jews: “Now the Gentiles have corrupted themselves we may expect that God in due time will make a new reformation.”⁵⁵

Thus, like the system of the world, the human sphere has destabilizing tendencies, and for Newton religion in particular tended to degenerate over time. In both his views of prophecy and his physics, time is a great corrupter: physical beings and physical entities tend to wind down, thus showing their dependence on the timeless and immutable deity. And in both his views of prophecy and his physics, the Lord God of Israel is the Great Restorer. It is perhaps noteworthy that on the same page that Newton outlined the patterns of apostasy and reformation in salvation history he also spoke about God’s omnipresence in the universe: “We are to conceive him void of external shape or bounds, a being intangible and invisible whom no eye hath seen or can see, and therefore also incorporeal. A being immoveable and the first cause of motion in all other things. For he is necessarily in all places alike so that no place can subsist without him or be emptier or fuller of him then it is by the necessity of nature.”⁵⁶

Newton’s biblical view of providence does not make a neat separation between providence in the natural world and intervention in human affairs. This may explain why the themes of degeneration and renewal, along with God’s role in these cycles, occur in Newton’s understanding of both prophetic history and cosmic history. But an awareness of Newton’s powerfully prophetic worldview also puts to rest another common myth about Newton, namely, that he was a deist or protodeist. Despite increasing evidence to the contrary, Richard Westfall maintained that Newton was a protodeist or religious rationalist who was racked by anxieties about the supposed erosion of the Christian faith in the face of the new authority of science.⁵⁷ Even without knowledge of his vast prophetic manuscripts it should be apparent that Newton’s conception of the universe is not that of a deist—not even a providentialist deist. But his prophetic manuscripts make this absolutely clear. No deist would accept biblical prophecy (of all genres in the Scriptures) as a revelation from God that has been fulfilled and will be fulfilled in history. No deist would hold to the millenarian views Newton embraced.⁵⁸ Newton’s views of providence in

the natural and human worlds accord with the classical theism of the Judeo-Christian tradition, not deism.

Perhaps the closest Newton came to applying the clockwork analogy to the universe is in the draft of a letter written around May 1712 and intended to respond to Leibniz in the pages of *Memoirs of Literature*. The letter remained unpublished, but near the end Newton argues that understanding that gravity can keep the planets in their courses without a miracle: “To understand the motions of the planets under the influence of gravity, without knowing the cause of gravity, is as good a progress in philosophy as to understand the frame of a clock, and the dependence of the wheels upon one another, without knowing the cause of the gravity of the weight which moves the machine, is in the philosophy of clockwork.”⁵⁹ Close though it may be, this argument has specific ends and falls short of an explicit description of the world as a clockwork mechanism. Newton did not have a view of the cosmos as a mechanical clock in the rational sense. He may not have even held a view of the cosmos as a clockwork in the pious sense of Kepler or Boyle.

Having worked hard to try to dispel one myth about Newton, I want to be exceptionally careful that I do not provide the seeds for an opposite myth, namely, that Newton’s system of the world was *primarily* dependent on ideas of God’s providence derived from Scripture. A reckless statement made recently by Christopher Hitchens helps demonstrate the propensity for such a reverse myth to develop. In a two-page advertisement sponsored by the John Templeton Foundation and containing statements on the relationship of science and religion from a range of notable figures, Hitchens offers the following declaration about Newton: “For Sir Isaac Newton—an enthusiastic alchemist, a despiser of the doctrine of the Trinity and a fanatical anti-Papist—the main clues to the cosmos were to be found in Scripture.”⁶⁰ Everything between the two em-dashes is true, although one may want to quibble about the use of the qualifier *fanatical*. What comes at the end of Hitchens’ declaration, however, is a gross distortion. No one who knows anything about the massive amounts of observational data and theoretical work Newton put into the development of his laws of motion and his theory of gravitation could make such a statement—at

least not in good faith. Yes, the evidence suggests that the *structure* of Newton's cosmology was in certain respects informed by his prophetic conception of God's providence. But let there be no mistake: while his commitments to a providentialist view of the universe cannot now be doubted, Newton's theology was not the primary source for his physics. Newton was an empiricist in his understanding of the cosmos. Although he believed that his physics was compatible with the Scriptures and that the *Principia* provided evidence for God's creative and sustaining hand at work, he nevertheless found the main clues to the cosmos in the cosmos.

Newton's Early Followers

How, then, did those who knew Newton best interpret his view of the universe? An authoritative witness can be found in the writings of the early Newtonians William Whiston, Samuel Clarke, Roger Cotes, and Colin Maclaurin. Whiston, who succeed Newton as Lucasian Professor of Mathematics at Cambridge, enjoyed intimate contact with Newton until the latter broke with him around 1714. Clarke was a close confidant of Newton who was also a near neighbor in London for most of the last two decades of Newton's life (as well as being Newton's parish priest). As already mentioned, he was the translator of the Latin edition of Newton's *Opticks*. Roger Cotes, a young Fellow of Trinity College who was also the Plumian Professor of Astronomy and Experimental Philosophy at Cambridge, was the editor of the second (1713) edition of Newton's *Principia*. As for Maclaurin, a Scottish mathematician who became an ardent supporter of Newton, although he did not enjoy the sustained contact with Newton that Whiston and Clarke did, he nevertheless knew Newton personally and had a detailed understanding of his physics, as evinced by the introduction to Newtonian physics he published in 1748.

Rather than turning immediately to these friends and acquaintances of Newton, we will start with the famous Leibniz-Clarke correspondence of 1715–16. Among other criticisms of Newton's thought, Gottfried Leibniz claimed the following in the fourth paragraph of his first paper:



Sir *Isaac Newton*, and his Followers, have also 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. He had not, it seems, sufficient Foresight to make it a perpetual Motion. Nay, the Machine of God's making, is so imperfect, according to these Gentlemen; that he is obliged to *clean* it now and then by an extraordinary Concourse, and even to *mend* it, as a Clockmaker mends his Work; Who must consequently be so much the more unskilful a Workman, as he is oftner obliged to mend his Work and to set it right.⁶¹

Leibniz's notion of a perpetual motion machine implies an idealized, clock of Platonic perfection; what he attributes to Newton is an unreliable clock that requires frequent rewinding—the kind of clock that would have been familiar to the original readers of this debate. In his note to the first published edition of the correspondence, Clarke surmises that Leibniz is here responding to the statement in the final query of the *Opticks*, where Newton contends that the irregularities of the comets and planets “will be apt to increase, till this System wants a Reformation.”⁶² And it does seem likely that Leibniz had this text in mind. Leibniz next contrasts Newton's putative view of things with his own understanding of the cosmos, the preestablished divine order, and the nature of miracles: “According to *My* Opinion, the *same* Force and Vigour remains always in the World, and only passes from one part of Matter to another, agreeably to the Laws of Nature, and the beautiful *pre-established* Order. And I hold, that when God works Miracles, he does not do it in order to supply the Wants of Nature, but those of *Grace*. Whoever thinks otherwise, must needs have a very mean Notion of the Wisdom and Power of God.”⁶³ Thus Leibniz lays down the gauntlet.

In the section of his first reply that corresponds to Leibniz's fourth paragraph, Clarke is careful to answer Leibniz's attribution to Newton of a divine Clockmaker without perfect foresight. First, Clarke argues against the analogy between God and the human clockmaker, noting that the latter is responsible for making the clock and its component parts but not the forces that drive it. These are “only *adjusted*, by the Workman.”⁶⁴ “But with regard to *God*, the Case is quite different;

because *He* not only composes or puts Things together, but is himself the Author and continual Preserver of their *Original Forces* or *moving Powers*: And consequently tis not a *diminution*, but the true *Glory* of his Workmanship, that *nothing* is done without his *continual Government* and *Inspection*.”⁶⁵

Thus, in contradistinction to Leibniz’s proposal, the Newtonian conception emphasizes God’s role as both creator and sustainer through continuous Providence. Far from cowering before Leibniz’s accusation of theological infelicity, Clarke takes the high road and declares God’s continuous care of the cosmos a thing worthy of great glory.

Second, Clarke offers a direct, forceful, and unambiguous repudiation of the clockwork analogy: “The Notion of the World’s being a great *Machine*, going on *without the Interposition of God*, as a Clock continues to go without the Assistance of a Clockmaker; is the Notion of *Materialism* and *Fate*, and tends, (under pretense of making God a *Supra-Mundane Intelligence*,) to exclude *Providence* and *God’s Government* in reality out of the World.”⁶⁶ Thus Clarke does not merely reject the clockwork analogy but, without hesitation, associates it with materialism and fate and, what is more, is at pains to emphasize the deleterious theological consequences of such a view of the cosmos for the sovereignty of God.

The remainder of Clarke’s reply to Leibniz’s use of the clockwork model involves the explication of two theological problems that could arise from viewing the cosmos as a clock. First, he presents a slippery-slope argument about Leibniz’s “pre-established order”: “And by the same Reason that a *Philosopher* can represent all Things going on from the beginning of the Creation, *without any Government* or *Interposition of Providence*; a *Sceptick* will easily argue still farther backwards, and suppose that Things have from Eternity gone on (as they now do) *without any true Creation* or *Original Author* at all, but only what such Arguers call *All-Wise and Eternal Nature*.”⁶⁷ Clarke here is prophetic. This is essentially what some thinkers in the eighteenth century began to argue.⁶⁸ His second concern is met with a royal analogy. Just as a king whose kingdom continued “*without his Government* or *Interposition*, or *without his Attending to and Ordering* what is done therein”

would in effect be merely a king of “a *Nominal Kingdom*” and not merit the titles “King or Governor,” so it would be with God if He did not exercise continuous dominion over the world—an argument that echoes the treatment of the God of continuous dominion in Newton’s General Scholium. Clarke also extends this analogy in an interesting way by arguing that just as treasonous men who in “Earthly Government” believe things can go on without the oversight of the king “may reasonably be suspected that they would like very well to set the King aside,” “whosoever contends, that the Course of the World can go on *without* the Continual direction of *God*, the Supreme Governor; his Doctrine does in Effect tend to Exclude God out of the World.”⁶⁹ Is Clarke suggesting that his opponent is guilty of some kind of theological sedition?

Although he does not explicitly say so, Clarke may also have been implying that Leibniz’s view of God’s action (or nonaction) in the world was tantamount to deism.⁷⁰ Clarke’s familiarity with Newton’s natural philosophy and theology endows his rejection of the clockwork analogy with a great deal of authority. The evidence of Newton’s behind-the-scenes involvement in Clarke’s responses to Leibniz also strongly suggests that Clarke’s statement either met with Newton’s approval or originated with Newton.⁷¹

Clarke added detail to his conception of Newton’s theologically informed cosmology in subsequent replies to Leibniz. In his second reply, Clarke further elaborates on his conception of God’s continuous providence. Agreeing with Leibniz that God’s workmanship should show both his power and his wisdom, Clarke argues: “This *Wisdom of God* appears, not in making Nature (as an Artificer makes a Clock) capable of going on *without him*: (For that’s *impossible*; there being *no Powers* of Nature *independent* upon *God*, as the *Powers* of *Weights* and *Springs* are *independent* upon *Men*;) But the *Wisdom of God* consists, in framing *originally* the *perfect* and *complete Idea* of a Work, which *begun* and *continues*, according to that Original perfect Idea, by the *continual uninterrupted Exercise* of his *Power* and *Government*.”⁷² Leibniz’s clockwork analogy, based as it is on the notion of the independent power of weights and springs, is theologically problematic precisely because it does not do justice to the continuous sovereignty of the Almighty.

Another notable statement comes in the tenth paragraph of his second reply, in which he declares that God is both transcendent over the world and immanent in the world: “God is neither a *Mundane* Intelligence, nor a *Supra-Mundane* Intelligence; but an *Omnipresent* Intelligence, both *In* and *Without* the World. He is *In* all, and *Through* all, as well as *Above* all.”⁷³ Clarke also denies that the only kind of “natural forces” are mechanical, contending that this would make animals and men “as *mere Machines* as a *Clock*.” “Natural forces” for Clarke are not to be exclusively equated with mechanical forces. If they are not (as Clarke argues), “then *Gravitation* may be effected by *regular* and *natural* Powers, though they be *not Mechanical*.”⁷⁴ Clarke rejects both the clockwork analogy and a universe that can be reduced to mere mechanism. Although Clarke provides a robust repudiation of Leibniz’s implied clockwork analogy, it seems likely that Leibniz’s criticism of Newton on this point ultimately fed into the common myth that Newton problematically introduced a clockwork universe.

Although Whiston does feel able to use the clockwork analogy for the purposes of the design argument, he too accepts only a strongly providentialist view of the universe.⁷⁵ Whiston does, however, employ the clockwork analogy in a way very similar to the way Leibniz does in this First Paper of 1715—albeit to very different ends. In his 1696 *New theory of the earth*, Whiston argues that God would have created the cosmos in such a way that “external Nature was even, uniform, and regular” but that the various eccentricities and anomalies now observed were the result of secondary causes.⁷⁶ “’Tis most Philosophical, as well as most Pious, to ascribe only what appears wise, regular, uniform, and harmonious, to the First Cause; (as the main *Phænomena* of the Heavenly Bodies, their Places, and Motions, do, to the degree of wonder and surprize) but as to such things as may seem of another nature, to attribute them intirely to subsequent changes, which the mutual actions of Bodies one upon another, fore-ordain’d and adjusted by the Divine Providence, in various Periods, agreeably to the various exigencies of Creatures, might bring to pass.”⁷⁷

This much is more or less consistent with the views of Newton and Clarke. But shortly after this, Whiston introduces the analogy of the clock to explain his distinction between the original perfection

and uniformity of the creation and its subsequent decline: “If any one of us should observe that a curious Clock, made and kept in order by an excellent Artist, was very notably different from the true time of the day, and took notice withal of a certain rub or stoppage, which was very capable of causing that Error in its Motion; he would easily and undoubtedly conclude that such an Error was truly occasion’d by that visible Impediment; and never design’d at first, or procur’d by the Artist.”⁷⁸ Two decades later, in his *Astronomical principles of religion* (1717), when speaking of those predisposed to accept the doctrine of the eternity of the world, Whiston compares the universe to a clock losing its motion over time. Whiston argues that such a person cannot suppose there to be an “Equality of Motion . . . in every Part of the Universe” and “that a certain Clock or Watch will of itself go for ever” while also observing “such wearing of the Wheels and Pivots, such decay of the Spring, and such Rust and Foulness over the whole, (besides the Necessity of its being wound up every Revolution) as must, by Calculation, put a Stop to its Motion in 20 Years time.”⁷⁹ Whiston completed his *Astronomical principles* on September 1, 1716, and the book appeared for sale in early April 1717,⁸⁰ so he likely composed this argument before becoming aware of Leibniz’s challenge to Newton using the example of the clockwork universe that requires constant rewinding.

But this language is consistent with Whiston’s advocacy of Newton’s argument against the eternity of the world based on the degeneration of the cosmos elsewhere in the same book, where he asserts that the stars and their systems “are not of Permanent and Eternal Constitutions; but that, unless a miraculous Power interposes, they must all, in length of Time, decay and perish, and be rendred utterly incapable of those noble Uses for which at present they are so wonderfully adapted.”⁸¹ Further clarification of Whiston’s views comes in his corollaries at the beginning of the *New theory*. In the first two corollaries Whiston contends that the power of gravity “is not a result from the Nature of Matter,” but rather that “this universal force of Gravitation being so plainly above, besides, and contrary to the Nature of Matter . . . must be the Effect of a Divine Power and Efficacy which governs the whole World, and which is absolutely necessary to its Preservation.”⁸² Additional detail comes

in the fifth corollary: “*The Providence of God in the Natural World is not merely a Conservation of its being, or a Non-annihilation thereof; but a constant, uniform, active Influence or Energy in all the Operations done in it.*”⁸³ If God were to withdraw this sustaining power, even if he preserved the being of the bodies of the world, “*the whole would immediately be dissolv’d, and each of the Heavenly Bodies be crumbled into Dust.*”⁸⁴ This is not deism or merely preordained design; this is the continuous providence of a truly omnipresent and everlasting God.

When Roger Cotes crafted his preface to the second edition of the *Principia*, he devoted some space to theological apologetics, including articulations of natural theology and the claim that Newton’s magnum opus acted as an incentive to piety as well as a buttress against atheism. His articulations of natural theology include echoes of the General Scholium’s design argument and God of dominion. Cotes writes: “Surely, this world—so beautifully diversified in its forms and motions—could not have arisen except from the perfectly free will of God, who provides and governs all things.”⁸⁵ Newton through his great work the *Principia* has “unlocked the gates” and “opened our way to the most beautiful mysteries of nature.” The *Principia* has now made it “possible to have a closer view of the majesty of nature, to enjoy the sweetest contemplation, and to worship and venerate more zealously the maker and lord of all.”⁸⁶ Once again, the emphasis is on the continuous sovereignty of God.

Finally, these themes reverberate in Colin Maclaurin’s 1748 *Account of Sir Isaac Newton’s philosophical discoveries*. Early in this book, Maclaurin rejects Epicureanism and all systems that view the universe in purely mechanical ways.⁸⁷ Toward the end of the book Maclaurin takes up themes relevant to the relationship between Newtonian physics and theology. Like Newton, he uses the example of the decay of the sun to argue against the eternity of the world. The argument against the eternity of the world is further bolstered by the new theory of comets, “since the supply which they afford must have been long ago exhausted, if the world had existed from eternity.”⁸⁸ Maclaurin also summarizes the arguments made in the General Scholium about God’s dominion, namely that “the structure of the visible world” demonstrates that it “is governed by *One Almighty, and All-Wise Being*, who rules the



world, not as its *Soul* but as its *Lord*, exercising an absolute sovereignty over the universe.”⁸⁹ Alluding to Leibniz’s views, Maclaurin states “that as the Deity is the first and supreme cause of all things, so it is most unaccountable to exclude him out of nature, and represent him as an *intelligentia extramundana*.”⁹⁰ He elaborates on this as follows:

On the contrary, it is most natural to suppose him to be the chief mover throughout the whole universe, and that all other causes are dependent upon him; and conformable to this is the result of all our enquiries into nature; where we are always meeting with powers that surpass mere mechanism, or the effects of matter and motion. The laws of nature are constant and regular, and, for ought we know, all of them may be resolved into one general and extensive power; but this power itself derives its properties and efficacy, not from mechanism, but, in a great measure, from the immediate influences of the first mover. It appears, however, not to have been his intention, that the present state of things should continue for ever without alteration; not only from what passes in the moral world, but from phænomena of the material world likewise; as it is evident that it could not have continued in its present state from eternity.⁹¹

Two elements of this passage are worthy of comment. First, we see Maclaurin explicitly deny mere mechanism and emphasize the necessary role of *supramechanical* powers. Second, Maclaurin strikingly asserts not only that the current state will not “continue for ever without alteration” but also that we know this in part from the analogy of the moral world. Here Maclaurin speaks with the same voice as Newton.

In sum, Newton’s closest followers reassert the central features of his theological conception of the world, including the role of supra-mechanical forces, the reality of processes of degeneration in the cosmos, the true rather than nominal omnipresence of God, and the rejection of mere mechanism and a God-banishing clockwork universe. When the clockwork analogy is raised (as it is by Whiston), it is used to describe a universe in perpetual decline rather than a static cosmos that has no need of the deity beyond the initial creative act. Newton’s

followers also echo the two most basic elements of Newton's theological conception of the world, that God is creator *and* sustainer; while Newton and the Newtonians embrace both elements, the deistic conception of the world accepts only the first element. Finally, it is noteworthy that these close followers of Newton were without exception antideistic in theological orientation.

Postscript on Newton and the Enlightenment

Newton was committed to a powerful biblical faith and saw his physics in providentialist terms. We have seen this in both Newton's own writings and his reception among his closest followers, who reassert the central features of his theological conception of the world. Yet in the decades after his death these important elements of his thought, already little known and not very well understood while he was alive, were distanced even further from Newton in the writings of both supporters and opponents. As Newton biographer Gale E. Christianson concludes: "Few things would have angered or dismayed him more than the Enlightenment belief that the *Principia* contained the framework of a universe in which God was no longer a vital, or even necessary, part."⁹² But this is precisely what occurred. Both popular and scholarly (mis)conceptions of Newton today are due in no small part to readings and misreadings of his thought during the European Enlightenment of the eighteenth century—readings and misreadings that led to a diversity of portrayals of Newton, some of them mutually contradictory. While space does not allow detailed elaboration, I think it is worth outlining six likely factors that can be identified as contributory to the distortion of Newton's thought during this time.⁹³

First, Newton engaged in self-censorship—no doubt motivated in part by his desire to conceal his antitrinitarian theological heresy. Second, Newton's own followers in Britain, some of them chosen by him, tended to emphasize the success of Newton's physics, champion his philosophical method, celebrate his genius, and explicate the natural theological relations of his work, while avoiding the wider theological dynamics of his thought.⁹⁴ Third, a number of less friendly

voices in Britain began to provide readings of Newton different from those being disseminated by the British Newtonians. On the one hand, a small number of deists and freethinkers began to radicalize his thought;⁹⁵ on the other hand, some vocal religious opponents of Newton's system in Britain began to contend that Newtonianism was bad for religion.⁹⁶ Fourth, the leading thinkers of the French Enlightenment, headed by Voltaire, produced deistic, secularizing, and even occasionally materialistic interpretations of Newton's physics. Voltaire himself was happy to point to elements of Newton's religion—such as his natural theology and antitrinitarianism—that he found compatible with his rationalism, but in his three major works popularizing Newton's physics he maintained a studied silence on Newton's prophetic beliefs—although elsewhere he derogates Newton's prophetic beliefs.⁹⁷ And nothing signals Newton's distance from the *philosophes* like his deep commitment to biblical prophecy and millenarianism. Fifth, the British Romantics—partly responding to distortions of Newton's thought already current—constructed an image of Newton as a cold, malevolent rationalist who helped bring about the God-banishing, soul-destroying, imagination-sapping, and materialistic forms of science that they decried in their poetry and prose.⁹⁸ William Blake epitomizes the Romantic reaction. It was he who wrote, “May God us keep / From Single vision & Newtons sleep.”⁹⁹ If only Blake had known Newton the alchemist and providentialist! Sixth, and finally, Newton's cosmology is read through the lens of Pierre-Simon de la Place, the “Newton of France” who transformed Newtonianism into the deterministic, clockwork universe that so many now anachronistically associate with Newton himself.

Such factors as these go a long way to explaining how Newton came to be known as the father of the deistic clockwork universe. Yet, thanks in large part to our access to the material hidden away by Newton's self-censorship, we are able to see how far removed such a portrait of Newton is from his actual visage. A careful reading of Newton's massive corpus, both published and unpublished, reveals that he was, without question, committed to biblical Christianity—even if not always orthodox—and understood his own work, particularly his physics, in providentialist terms, reflective of his theistic and prophetic



understanding of the cosmos. In a certain sense, Blake was right. Newton had a single vision rather than a double vision. But it was a single vision of the cosmos as a whole that contained both matter and spirit and that involved both nature and the superintendence of the God of Israel.

Notes

For helpful discussions about the themes of this essay, I would like to thank Edward Davis, Mordechai Feingold, Andrew Janiak, and Jeffrey Wigelsworth. I am also grateful to the two editors of this volume for their help and advice.

1. Johnjoe McFadden, “‘Survival of the Wisest’: It Is 150 Years since Darwin Expounded the Theory That Illuminates Our World to This Day,” *Guardian*, June 30, 2008. For similar caricatures, see also Christopher Hitchens, *God Is Not Great: How Religion Poisons Everything* (Toronto: McClelland and Stewart, 2007), 80; Carl Sagan, *The Varieties of Scientific Experience: A Personal View of the Search for God*, ed. Ann Druyan (New York: Penguin Press, 2006), 63–64; Robert M. Hazen and James Trefil, *Science Matters: Achieving Scientific Literacy* (1991; repr., New York: Anchor Books, 1992), 5, 14; Roger S. Jones, *Physics for the Rest of Us: Ten Basic Ideas of Twentieth-Century Physics That Everyone Should Know . . . and How They Have Shaped Our Culture and Consciousness* (Chicago: Contemporary Books, 1992), 101–2; Paul Davies and John Gribbin, *The Matter Myth: Dramatic Discoveries That Challenge Our Understanding of Physical Reality* (New York: Touchstone, 1992), 12, 13, 15, 17, 42, 62, 221, 260; Peter Aughton, *The Story of Astronomy: From Babylonian Stargazers to the Search for the Big Bang* (London: Quercus, 2008), 80–91; Ivars Peterson, *Newton’s Clock: Chaos in the Solar System* (New York: W. H. Freeman, 1993); Richard Baum and William Sheehan, *In Search of Planet Vulcan: The Ghost in Newton’s Clockwork Universe* (New York: Plenum, 1997); John David Ebert, *Twilight of the Clockwork God: Conversations on Science and Spirituality at the End of an Age* (San Francisco: Council Oak Books, 1999); Fritjof Capra, *The Web of Life: A New Scientific Understanding of Living Systems* (New York: Anchor Books, 1996), 5, 19, 20, 107, 120, 188, and *The Turning Point: Science, Society, and the Rising Culture* (1982; repr., Toronto: Bantam Books, 1983), 53–74, 99 (heading of Part III) and 164–87 (chapter entitled “Newtonian Psychology”); Franz J. Brosch, *Ecocide: A Short History of the Mass Extinction of Species* (London: Pluto Press, 2002), 57; Jane Jakeman, *Newton: A Beginner’s Guide* (Abingdon: Hodder and Stoughton, 2001), 63. An increasingly popular source of knowledge is the online encyclopedia Wikipedia. For several years up to early 2011, its entry “Clockwork Universe Theory” asserted that the clockwork universe was “established by Isaac New-



ton.” Happily, Ted Davis’s enterprising students have now corrected the entry, which now stresses that Newton *opposed* the clockwork universe theory (Ted Davis, pers. comm., August 8, 2011).

2. Often presented in tandem with the clockwork myth is the claim that Newton himself did not realize that his physics spelled the end of faith. See, e.g., Steven Weinberg, letter to the editor, *Times Literary Supplement*, February 16, 2007, http://entertainment.timesonline.co.uk/tol/arts_and_entertainment/the_tls/article2341817.ece. However, there have also been attempts to correct mythologies about Newton in the public sphere. See, e.g., Jean F. Drew, “Newton vs. the Clockwork Universe,” July 19, 2004, www.freerepublic.com/focus/f-news/1174268/posts.

3 “Beyond the Big Bang,” *The Universe*, History Channel, 2007, video clip of extra feature available at www.history.com/shows/the-universe/videos/playlists/beyond-the-big-bang#beyond-the-big-bang-sir-isaac-newtons-law-of-gravity (current as of August 12, 2011). One assumes that if Professor Kaku had committed a scientific solecism in his interview, it would have been caught and thus not included in the documentary. However, in science documentaries errors about the history of science or theology do not seem to receive this kind of scrutiny.

4. Edward Dolnick, *The Clockwork Universe: Isaac Newton, the Royal Society and the Birth of the Modern World* (New York: Harper, 2011).

5. To be sure, the Newtonian clockwork myth has not completely disappeared among scholars today. See, e.g., William A. Stahl et al., *Webs of Reality: Social Perspectives on Science and Religion* (New Brunswick: Rutgers University Press, 2002), 81. On the role of the scholarly community in perpetuating the myth, see, e.g., George S. Brett, “Newton’s Place in the History of Religious Thought,” in *Sir Isaac Newton, 1727–1927: A Bicentenary Evaluation of His Work*, ed. F. E. Brasch (Baltimore: Williams and Williams, 1928), 263; and Samuel Leslie Bethell, *The Cultural Revolution of the Seventeenth Century* (London: D. Dobson, 1951), 63. To be fair to scholars of this earlier era, assessments of Newton’s thought was of necessity limited mostly to his published works.

6. See, e.g., J. E. McGuire and P. M. Ratansi, “Newton and the ‘Pipes of Pan,’” *Notes and Records of the Royal Society of London* 21 (1966): 108–42; David Kubrin, “Newton and the Cyclical Cosmos: Providence and the Mechanical Philosophy,” *Journal of the History of Ideas* 28 (1967): 325–45, and “Providence and the Mechanical Philosophy: The Creation and the Dissolution of the World in Newtonian Thought” (PhD diss., Cornell University, 1968); J. E. McGuire, “Force, Active Principles, and Newton’s Invisible Realm,” *Ambix* 15 (1968): 154–208, and *Tradition and Innovation: Newton’s Metaphysics of Nature* (Dordrecht: Kluwer, 1995); Frank E. Manuel, *The Religion of Isaac Newton* (Oxford: Clarendon Press, 1974); Betty Jo Teeter Dobbs, *The Foundations of Newton’s Alchemy: The Hunting of the Greene Lyon* (Cambridge: Cambridge University Press, 1975) and

The Janus Faces of Genius: The Role of Alchemy in Newton's Thought (Cambridge: Cambridge University Press, 1991); Richard S. Westfall, *Never at Rest: A Biography of Isaac Newton* (Cambridge: Cambridge University Press, 1980); Gale E. Christianson, *In the Presence of the Creator: Isaac Newton and His Times* (New York: Free Press, 1984); James E. Force and Richard H. Popkin, *Essays on the Context, Nature, and Influence of Isaac Newton's Theology* (Dordrecht: Kluwer, 1990); James E. Force and Richard H. Popkin, eds., *Newton and Religion: Context, Nature and Influence* (Dordrecht: Kluwer, 1999); James E. Force, "Newton and Deism," in *Science and Religion / Wissenschaft und Religion*, ed. Anne Bäumer and Manfred Büttner (Büchum: Brockmeyer, 1989), 120–32, and "Newton's God of Dominion: The Unity of Newton's Theological, Scientific and Political Thought," in Force and Popkin, *Essays on the Context*, 75–102; Edward B. Davis, "Newton's Rejection of the 'Newtonian World View': The Role of Divine Will in Newton's Natural Philosophy," *Fides et Historia* 22 (1990): 6–20, republished in *Science and Christian Belief* 3 (1991): 103–17 and, with additions, in *Facets of Faith and Science*, vol. 3, *The Role of Beliefs in the Natural Sciences*, ed. Jitse M. van der Meer (Lanham: University Press of America, 1996), 75–96, and "Myth 13: That Isaac Newton's Mechanistic Cosmology Eliminated the Need for God," in *Galileo Goes to Jail and Other Myths about Science and Religion*, ed. Ronald L. Numbers (Cambridge, MA: Harvard University Press, 2009), 115–22; Edward B. Davis and Robin Collins, "Scientific Naturalism," in *The History of Science and Religion in the Western Tradition: An Encyclopedia*, ed. Gary B. Ferngren (New York: Garland, 2000), 203; Edward B. Davis and Michael P. Winship, "Early-Modern Protestantism," in Ferngren, *History of Science*, 283–84; Otto Mayr, "Clockwork Universe," in *Encyclopedia of the Scientific Revolution: From Copernicus to Newton*, ed. Wilbur Applebaum (New York: Garland, 2000), 145; William E. Burns, *The Scientific Revolution: An Encyclopedia* (Santa Barbara, CA: ABC-CLIO, 2001), 240; Dan Falk, *In Search of Time: Journeys along a Curious Dimension* (Toronto: McClelland and Stewart, 2008), 134; Keith Ward, *Pascal's Fire: Scientific Faith and Religious Understanding* (Oxford: Oneworld Publications, 2006), 24–33, 40–48, 108; Alvin Plantinga, "What Is 'Intervention'?" *Theology and Science* 6 (2008): 369–401.

7. Cf. Christopher B. Kaiser, *Creational Theology and the History of Physical Science: The Creationist Tradition from Basil to Bohr* (Leiden: Brill, 1997), 108.

8. See John North, *God's Clockwork: Richard of Wallingford and the Invention of Time* (London: Continuum, 2005), 201. Otto Mayr sees the notion of the *machina mundi* as a stepping stone to the clockwork metaphor. See Mayr, "Clockwork Universe," 146.

9. Copernicus, *On the Revolutions*, vol. 2, ed. Jerzy Dobrzycki, trans. Edward Rosen (London: Macmillan, 1978), 4.

10. Nicole Oresme, *Le livre du ciel et du monde* 2.2, cited in Edward Grant, *A History of Natural Philosophy: From the Ancient World to the Nineteenth Century* (Cambridge: Cambridge University Press, 2007), 284. See also Kaiser, *Creational The-*



ology, 106–7. Mayr dates Oresme's first conception of the world as a clockwork to ca. 1350. See Mayr, "Clockwork Universe," 146.

11. See North, *God's Clockwork*, 202; and Kaiser, *Creational Theology*, 107–8.

12. Mayr, "Clockwork Universe," 145–46.

13. Stanley L. Jaki, "God, Nature, and Science," in Ferngren, *History of Science*, 48.

14. William B. Ashworth Jr., "Catholicism and Early Modern Science," in *God and Nature: Historical Essays on the Encounter between Christianity and Science*, ed. David C. Lindberg and Ronald L. Numbers (Berkeley: University of California Press, 1986), 138.

15. William B. Ashworth Jr., "Christianity and the Mechanistic Universe," in *When Science and Christianity Meet*, ed. David C. Lindberg and Ronald L. Numbers (Chicago: University of Chicago Press, 2003), 72–74; Pierre Gassendi, *Synagma philosophicum*, cited in Margaret J. Osler, "Whose Ends? Teleology in Early Modern Natural Philosophy," *Osiris* 16 (2001): 159.

16. René Descartes, *Philosophical Essays and Correspondence*, ed. Roger Ariew (Indianapolis: Hackett, 2000), 42–43, 69, 73, 138, 270–71, 276. See also Ashworth, "Christianity," 70, 74. For an argument that God plays a continuing role in Descartes's universe, see Gary Hatfield, "Force (God) in Descartes' Physics," *Studies in History and Philosophy of Science* 10 (1979): 113–40.

17. On Boyle's version of the mechanical philosophy, see Margaret G. Cook, "Divine Artifice and Natural Mechanism: Robert Boyle's Mechanical Philosophy of Nature," *Osiris* 16 (2001): 133–50; and Eugene Klaaren, *Religious Origins of Modern Science* (Grand Rapids, MI: Eerdmans, 1977), 149–59.

18. See Kepler to Herwart von Hohenburg, February 10, 1605, quoted in the original Latin in Alexandre Koyré, *The Astronomical Revolution: Copernicus—Kepler—Borelli*, trans. R. E. W. Maddison (1973; repr., New York: Dover Publications, 1992), 378: "My aim is this, to show that the celestial machine is not like a divine creature, but like a clock (he who believes the clock to be animate assigns the glory of the artificer to the work), insofar as nearly all the diversity of motions are caused by a simple, magnetic and corporeal force, just as all the motions of a clock are caused by a most simple weight. I will also show how this physical account is to be brought under mathematics and geometry" (my translation).

19. Klaaren, *Religious Origins*, 149.

20. See Ashworth, "Christianity."

21. For recent studies on the relationship between Newton's science and his religion, see Stephen D. Snobelen, "To Discourse of God: Isaac Newton's Heterodox Theology and His Natural Philosophy," in *Science and Dissent in England, 1688–1945*, ed. Paul B. Wood (Aldershot: Ashgate, 2004), 39–65, and James E. Force, "The Nature of Newton's 'Holy Alliance' between Science and Religion: From the Scientific Revolution to Newton (and Back Again)," in



Rethinking the Scientific Revolution, ed. Margaret J. Osler (Cambridge: Cambridge University Press, 2000), 247–70.

22. Some use this misconception—and others the *relative* lack of theological language in the first edition—to argue that the addition of the General Scholium in 1713 represents a turn to theology and a turn away from theological neutrality in the *Principia*. The accessibility of Newton’s theological manuscripts, many of which predate the *Principia*, along with a better understanding of the theological contexts of the work, has rendered this position untenable. On the continuing presence of theology in all three editions of the *Principia*, see I. Bernard Cohen, “Isaac Newton’s *Principia*, the Scriptures, and the Divine Providence,” in *Philosophy, Science, and Method: Essays in Honor of Ernest Nagel*, ed. Sidney Morgenbesser, Patrick Suppes, and Morton White (New York: St. Martin’s Press, 1969), 523–48. See also Stephen D. Snobelen, “The Theology of Isaac Newton’s *Principia mathematica*: A Preliminary Survey,” *Neue Zeitschrift für Systematische Theologie und Religionsphilosophie* 52 (2010): 377–412.

23. Isaac Newton, *The Principia: Mathematical Principles of Natural Philosophy*, trans. I. Bernard Cohen and Anne Whitman with Julia Budnez (Berkeley: University of California Press, 1999), 413–14. The Cohen-Whitman translation of the *Principia* is based on the third (1726) edition.

24. Newton, *Principia*, 814 n. cc.

25. Newton, *Principia*, 814–15.

26. See Cohen, “Isaac Newton’s *Principia*,” and Snobelen, “Theology of Newton’s *Principia*.”

27. For a recent edition of “De gravitatione,” see Isaac Newton, *Philosophical Writings*, ed. Andrew Janiak (Cambridge: Cambridge University Press, 2004), 12–39.

28. For background, see Henry Guerlac and Margaret Candee Jacob, “Bentley, Newton and Providence (the Boyle Lectures Once More),” *Journal of the History of Ideas* 30 (1969): 307–18.

29. Newton to Bentley, December 10, 1692, in Newton, *Philosophical Writings*, 94.

30. Newton to Bentley, December 10, 1692, in Newton, *Philosophical Writings*, 96.

31. Newton to Bentley, January 17, 1693, in Newton, *Philosophical Writings*, 98.

32. Newton to Bentley, February 25, 1693, in Newton, *Philosophical Writings*, 103. A 1698 memorandum by the Scottish mathematician David Gregory is also suggestive: “Mr C. Wren says that he is in possession of a method of explaining gravity mechanically. He smiles at Mr Newton’s belief that it does not occur by mechanical means, but was introduced originally by the Creator.” *The Correspondence of Sir Isaac Newton*, ed. J. F. Scott (Cambridge: Cambridge University Press, 1967), 4:267.

33. Richard Bentley, *A confutation of atheism from the origin and frame of the world. The third and last part* (London, 1693), 32.

34. Isaac Newton, Classical Scholia, in David Gregory MS. 245, fol. 14a, Library of the Royal Society, quoted in English in McGuire, “Force, Active Principles,” 216.

35. Newton, Cambridge University Library, Add MS 3965.6, fol. 266v.

36. Newton, Classical Scholia, in Volkmar Schüller, “Newton’s *Scholia* from David Gregory’s Estate on the Propositions IV through IX Book III of His *Principia*,” in *Between Leibniz, Newton, and Kant: Philosophy and Science in the Eighteenth Century*, ed. Wolfgang Lefèvre (Dordrecht: Kluwer, 2001), 241. See also Newton, Cambridge University Library Add. MS. 3965.12, fol. 269, cited in McGuire and Rattansi, “Newton,” 120. See also Newton, Cambridge University Library Add. MS. 3965.12, fol. 269, cited in McGuire and Rattansi, “Newton,” 120.

37. Betty Jo Teeter Dobbs, “Newton’s Alchemy and His Theory of Matter,” *Isis* 73 (1982): 511–28.

38. On the theology of the General Scholium, see Stephen D. Snobelen, “‘God of Gods, and Lord of Lords’: The Theology of Isaac Newton’s General Scholium to the *Principia*,” *Osiris* 16 (2001): 169–208; Larry Stewart, “Seeing through the Scholium: Religion and Reading Newton in the Eighteenth Century,” *History of Science* 34 (1996): 123–64.

39. Newton, *Principia*, 940.

40. Newton, *Principia*, 940.

41. John Calvin, *Concerning the Eternal Predestination of God*, trans. J. K. S. Reid (London: James Clarke, 1961), 162.

42. Newton, *Principia*, 940. Newton later makes it clear that God is “not at all corporeal” (942).

43. Newton, *Principia*, 941.

44. Newton, *Principia*, 941–42.

45. Newton, *Principia*, 941–42 n. j. The note on space was enlarged for the 1726 edition.

46. Newton, *Principia*, 943.

47. Newton, *Principia*, 940.

48. Isaac Newton, *Isaac Newton’s Philosophiæ naturalis principia mathematica: The Third Edition (1726) with Variant Readings*, ed. I. Bernard Cohen and Alexandre Koyré (Cambridge, MA: Harvard University Press, 1972), 2:760. Michael A. Hoskins points to the significance of this variant reading when discussing the difference between the cosmologies of Leibniz and Newton in “Newton and the Beginnings of Stellar Astronomy,” in *Newton and the New Direction in Science*, ed. G. V. Coyne, M. Heller, and J. Życiński (Vatican City: Specola Vaticana, 1988), 60. I have adapted Hoskins’s translation to bring out with greater clarity Newton’s description of God and his will (Hoskins has simply “the divine plan”).

49. A survey of theological themes in the various editions of the *Opticks* can be found in Stephen D. Snobelen, “‘La lumière de la nature’: Dieu et la philosophie naturelle dans l’*Optique* de Newton,” *Lumières* 4 (2004): 65–104.
50. Isaac Newton, *Opticks: or, a treatise of the reflexions, refractions, inflexions and colours of light* (London, 1717), 344.
51. Newton, *Opticks* [1717], 372–73.
52. Newton, *Opticks* [1717], 375.
53. Newton, *Opticks* [1717], 378.
54. Isaac Newton, “Irenicum,” Keynes MS 3, 35 (normalized text).
55. Newton, “Irenicum,” 35.
56. Newton, “Irenicum,” 35.
57. Various iterations of Westfall’s protodeist and incipient rationalist theses can be found in Richard S. Westfall, “Newton and Christianity,” in *Religion, Science and Public Policy*, ed. Frank T. Birtel (New York: Crossroad, 1987), “The Rise of Science and the Decline of Orthodox Christianity: A Study of Kepler, Descartes, and Newton,” in Lindberg and Numbers, *God and Nature*, 218–37, and “Isaac Newton’s *Theologiae gentilis origines philosophicae*,” in *The Secular Mind: Transformations of Faith in Modern Europe*, ed. W. Warren Wagar (New York: Holmes and Meier, 1982), 15–34, *Science and Religion in Seventeenth-Century England* (New Haven: Yale University Press, 1958), 193–220, and “Isaac Newton: Religious Rationalist or Mystic?,” *Review of Religion* 22 (1957–8): 155–70. Westfall was still insisting on this view of Newton’s secularizing role in culture and the history of ideas in one of his last papers, published after his death. See Richard S. Westfall, “The Scientific Revolution Reasserted,” in Osler, *Rethinking the Scientific Revolution*, 54. It is possible that Westfall’s position was shaped by the mistaken belief that Newton’s biblicist antitrinitarian theology was either incipient deism or tantamount to deism.
58. James Force has provided the most robust criticisms of Westfall’s protodeism thesis. See James E. Force, “Samuel Clarke’s Four Categories of Deism, Isaac Newton, and the Bible,” in *Scepticism in the History of Philosophy*, ed. Richard H. Popkin (Dordrecht: Kluwer, 1996), 53–74, “Newton and Deism,” 120–32, and “The Newtonians and Deism,” in Force and Popkin, *Essays on the Context*, 43–73.
59. Newton to the editor of *Memoirs of Literature*, ca. May 1712, in *Philosophical Writings*, 117.
60. “Does Science Make Belief in God Obsolete?,” advertisement, *Atlantic*, May 2008, 44–45.
61. Gottfried Leibniz, “First Paper,” in *A collection of papers, which passed between the late learned Mr. Leibnitz, and Dr. Clarke, in the years 1715 and 1716* (London, 1717), 3, 5. The correspondence between Leibniz and Clarke was conducted in French but was published in 1717 with an English translation by Clarke

facing the original French. The English text of the 1717 edition is available at www.newtonproject.sussex.ac.uk.

62. Samuel Clarke, *Collection of papers*, 5 n *. Leibniz would have been referring to Clarke's 1706 Latin translation of the *Opticks* (Newton, *Optice*, 345–46). In this edition the final query was numbered 23.

63. Leibniz, "First Paper," 5.

64. Samuel Clarke, "First Reply," in *Collection of papers*, 13 and 15 (quotation on 15).

65. Clarke, "First Reply," 15.

66. Clarke, "First Reply," 15.

67. Clarke, "First Reply," 15 and 17.

68. It also roughly corresponds to the position of modern pantheists and materialists. One is reminded of Carl Sagan's opening statement in his 1980 documentary *Cosmos*: "The cosmos is all that is or ever was or ever will be," a secular inversion of Rev. 1:8.

69. Clarke, "First Reply," 17.

70. See Clarke's arguments against deism and his quadripartite taxonomy of deism in his 1705 Boyle Lectures: Samuel Clarke, *A discourse concerning the unchangeable obligations of natural religion, and the truth and certainty of the Christian revelation* (London, 1706), 19–45.

71. I. Bernard Cohen and Alexandre Koyré, "Newton and the Leibniz-Clarke Correspondence," *Archives Internationales d'Histoire des Sciences* 15 (1962): 63–126; A. Rupert Hall and Marie Boas Hall, "Clarke and Newton," *Isis* 52 (1961): 583–85. This is not to say that Clarke was merely Newton's mouthpiece or that he showed no originality in the debate.

72. Clarke, "Second Reply," in *Collection of papers*, 45.

73. Clarke, "Second Reply," 47.

74. Clarke, "Fourth Reply," in *Collection of papers*, 151.

75. For Whiston's use of the clockwork analogy, see William Whiston, *Astronomical principles of religion, natural and reveal'd* (London, 1717), 106, 255.

76. William Whiston, *New theory of the earth* (1696), 114–15 (quotation on 115).

77. Whiston, *New theory*, 116.

78. Whiston, *New theory*, 116–17.

79. Whiston, *Astronomical principles*, 109–10.

80. Whiston, *Astronomical principles*, 301; *Daily Courant*, advertisement, April 4, 1717.

81. Whiston, *Astronomical principles*, 89–90.

82. Whiston, *New theory*, 5–6.

83. Whiston, *New theory*, 6.

84. Whiston, *New theory*, 6–7.

85. Roger Cotes, preface to Newton, *Principia*, 397.
86. Cotes, preface to Newton, *Principia*, 398.
87. Colin Maclaurin, *An account of Sir Isaac Newton's philosophical discoveries, in four books* (London, 1748), 4–5.
88. Maclaurin, *Account*, 375–76.
89. Maclaurin, *Account*, 377.
90. Maclaurin, *Account*, 387.
91. Maclaurin, *Account*, 387.
92. Christianson, *In the Presence*, 60.
93. On Newton in the Enlightenment, see Stephen D. Snobelen, ed., “Isaac Newton in the Eighteenth Century,” special issue, *Enlightenment and Dissent* 25 (2009); J. B. Shank, *The Newton Wars and the Beginning of the French Enlightenment* (Chicago: University of Chicago Press, 2008); Jonathan I. Israel, *Enlightenment Contested: Philosophy, Modernity, and the Emancipation of Man, 1670–1752* (Oxford: Oxford University Press, 2006), 201–22, 751–80; Brian Young, “Newtonianism and the Enthusiasm of Enlightenment,” *Studies in the History and Philosophy of Science* 35 (2004): 645–63; Stephen D. Snobelen, “Isaac Newton,” in *Encyclopedia of the Enlightenment*, ed. Alan Charles Kors (Oxford: Oxford University Press, 2003), 3:172–77; Jonathan I. Israel, *Radical Enlightenment: Philosophy and the Making of Modernity, 1650–1750* (Oxford: Oxford University Press, 2001), 515–27; Paolo Casini, “Newton’s *Principia* and the Philosophers of the Enlightenment,” *Notes and Records of the Royal Society of London* 42 (1988): 35–52; P. M. Rattansi, “Voltaire and the Enlightenment Image of Newton,” in *History and Imagination: Essays in Honour of H. R. Trevor-Roper*, ed. Hugh Lloyd-Jones, Valerie Pearl, and Blair Worden (London: Duckworth, 1981), 218–31; Robert E. Schofield, “An Evolutionary Taxonomy of Eighteenth-Century Newtonianisms,” *Studies in Eighteenth-Century Culture* 7 (1978): 175–92; Margaret C. Jacob, “Newtonianism and the Origins of the Enlightenment: A Reassessment,” *Eighteenth-Century Studies* 11 (1977–78): 1–25; Peter Gay, *The Enlightenment: The Science of Freedom* (New York: W. W. Norton, 1969), 2:128–50 (the sections “The Enlightenment’s Newton” and “Newton’s Physics without Newton’s God”); Henry Guerlac, “Newton’s Changing Reputation in the Eighteenth Century” [1965], “Where the Statue Stood: Divergent Loyalties to Newton in the Eighteenth Century” [1965], and “Three Eighteenth-Century Social Philosophers: Scientific Influences on Their Thought” [1958], all in *Essays and Papers in the History of Modern Science* (Baltimore: John Hopkins University Press, 1977), 69–81, 131–45, and 451–64, respectively.
94. See Patricia Fara, *Newton: The Making of Genius* (London: Macmillan, 2002); Maureen McNeil, “Newton as National Hero,” in *Let Newton Be! A New Perspective on His Life and Works*, ed. John Fauvel et al. (Oxford: Oxford University Press, 1988), 223–39. The notable exception is William Whiston, who published extensively on prophecy (although Newton is only one of the sources of



his prophetic and strongly millennial ideas). On Whiston's prophetic views, see Stephen D. Snobelen, "William Whiston: Natural Philosopher, Prophet, Primitive Christian" (PhD diss., University of Chicago, 2000), ch. 4; James E. Force, *William Whiston: Honest Newtonian* (Cambridge: Cambridge University Press, 1985); and Maureen Farrell, *William Whiston* (New York: Arno Press, 1981).

95. See, e.g., John Toland, *Letters to Serena* (London, 1706), 183. Two valuable studies of Toland's appropriation of Newton are Jeffrey R. Wigelsworth, "Lockean Essences, Political Posturing, and John Toland's Reading of Isaac Newton's *Principia*," *Canadian Journal of History* 38 (2003): 521–35; and Margaret C. Jacob, "John Toland and the Newtonian Ideology," *Journal of the Warburg and Courtauld Institutes* 32 (1969): 307–31. See also Wigelsworth's more recent study "A Sheep in the Midst of Wolves: Reassessing Newton and English Deists," *Enlightenment and Dissent* 25 (2009): 260–86. Wigelsworth sees Toland as a kind of deist, while Jacob portrays him as a kind of pantheist, and thus more radical. On Toland and Newton, see also Shank, *Newton Wars*, 126–29, and Jacob, *The Newtonians and the English Revolution, 1689–1720* (Hassocks, Sussex: Harvester Press, 1976), 201–50.

96. Orthodox concerns over Newton's heterodoxy are explored in Scott Mandelbrote, "Eighteenth-Century Reactions to Newton's Anti-Trinitarianism," in *Newton and Newtonianism: New Studies*, ed. James E. Force and Sarah Hutton (Dordrecht: Kluwer, 2004), 93–111; Stephen D. Snobelen, "Isaac Newton, Heretic: The Strategies of a Nicodemite," *British Journal for the History of Science* 32 (December 1999): 381–419. See also George Hickes to Roger North, May 23, 1713, British Library Add. MS, 32551, fol. 34; Joseph Spence, *Observations, Anecdotes, and Characters of Books and Men Collected from Conversation*, ed. James M. Osborn (Oxford: Clarendon Press, 1966), 1:387; George Berkeley, *A treatise concerning the principles of human knowledge* (London, 1710), 156–68 (secs. 110–17). For more on Berkeley's anti-Newtonianism, see Fara, *Making of Genius*, 103–5; M. Hughes, "Newton, Hermes and Berkeley," *British Journal for the Philosophy of Science* 43 (1992): 1–19; Geoffrey N. Cantor, "Anti-Newton," in Fauvel et al., *Let Newton Be!*, 212–15; D. J. Greene, "Smart, Berkeley, the Scientists and the Poets: A Note on Eighteenth-Century Anti-Newtonianism," *Journal of the History of Ideas* 14 (1953): 327–52.

97. Voltaire, *Letters concerning the English nation* (London, 1733), *The Elements of Sir Isaac Newton's Philosophy*, trans. John Hanna (London, 1738), and *The Metaphysics of Sir Isaac Newton*, trans. David Erskine Baker (London, 1747). For Voltaire's discomfort with Newton's prophetic studies, see, for example, the reference to Newton in the entry "Esprit faux" ("False minds") in his *Dictionnaire philosophique, II*, vol. 36 of *The Complete Works of Voltaire* (Oxford: Voltaire Foundation, 1994), 63. On the reception of Newton in France, see Shank, *Newton Wars*; Derek Gjertsen, "Newton in France," in *The Newton Handbook* (London: Routledge and Kegan Paul, 1986), 382–84; A. Rupert Hall, "Newton in France: A





New View,” *History of Science* 13 (1975): 233–50; I. Bernard Cohen, “Isaac Newton, Hans Sloane, and the Académie Royale des Sciences,” in *Mélanges Alexandre Koyré*, ed. I. Bernard Cohen and René Taton (Paris: Hermann, 1964), 1:61–116; Charles Coulston Gillispie, “Fontenelle and Newton,” in *Isaac Newton’s Papers and Letters on Natural Philosophy*, ed. I. Bernard Cohen (Cambridge, MA: Harvard University Press, 1958), 427–43. The classic study is Pierre Brunet, *L’introduction des théories de Newton en France au XVIII^e siècle, I: Avant 1738* (Paris: Librairie Scientifique Albert Blanchard, 1931). No further volumes were published.

98. For an overview, see Cantor, “Anti–Newton,” 203–21.

99. William Blake to Thomas Butts, November 22, 1802, in *The Complete Poetry and Prose of William Blake*, ed. David V. Erdman (New York: Anchor Books, 1982), 722.

