THE NEW ATLANTIS
A Journal of Technology & Society

The Unknown Newton

Cosmos and Apocalypse

Stephen D. Snobelen

There is a rather curious item among the papers of the philosopher John Locke. Scrawled on a single sheet archived with his personal manuscripts at the University of Oxford's Bodleian Library, it is a chart with seven columns of five to six vertical registers apiece (shown opposite). Locke's note on the reverse gives the year as 1691. But the handwriting on the chart itself is Isaac Newton's. Its contents? Not mathematics (although there are proportions and numbers), not political theory (although political figures are named), not a précis of empiricism (although it is exceptionally empirical in its own way), but the Apocalypse—the Bible's prophetic grand finale. To be more precise, this little document is a time chart depicting how the various dramatic prophecies of the book of Revelation have been and will be fulfilled in history through the guidance of divine Providence.

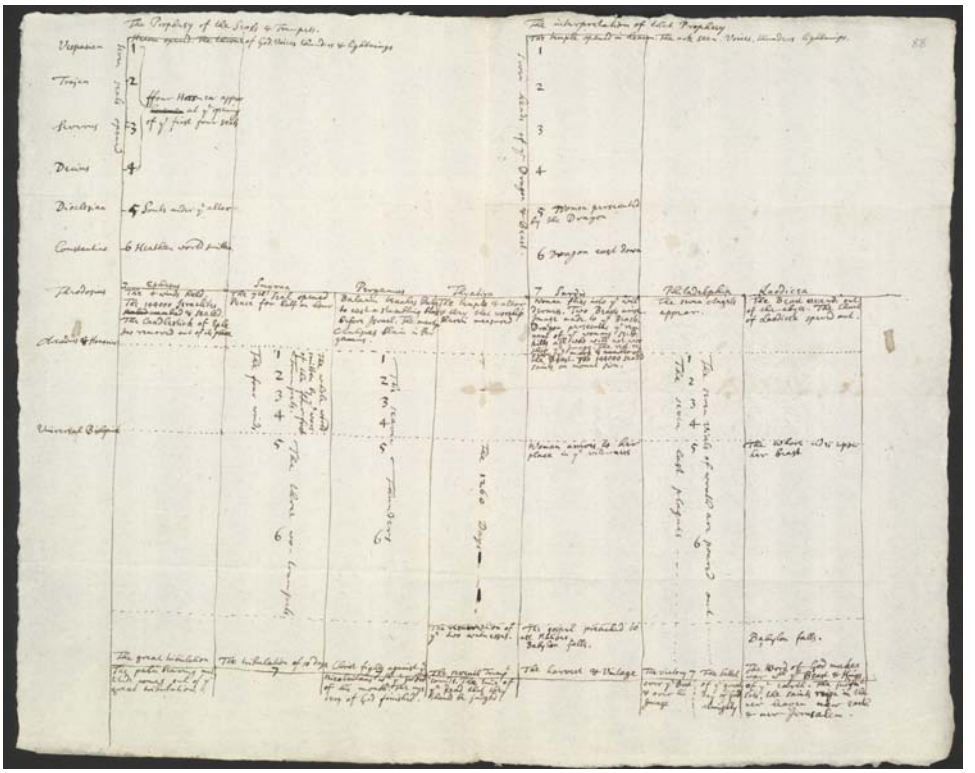
A comparison of this chart with Newton's much more detailed prophetic manuscripts confirms that it outlines the following events: the advance of the Four Horsemen in the early Church; the collapse of pagan Rome; God's judgment on the Roman Empire and its vestiges through the Barbarian, Arab, and Ottoman invasions; the rise of apostate Roman Catholicism; and the 1,260 years of the deepest corruption of the Trinitarian Church, when the Great Whore rides the Beast. All these are followed, near the bottom of the chart, by the fall of Babylon (that is, the Church of Rome); the Battle of Armageddon; the Day of Judgment; and the millennial reign of the saints with Christ in the new heaven, the new earth, and the new Jerusalem.

According to the popular conception of Newton as chiefly a scientist—one of the greatest and most rational of all time—this chart may appear simply as an antiquarian exploration of history or a mere literary exercise aimed at mapping the symbolic architectonics of the Apocalypse. But

Stephen D. Snobelen *is associate professor of history of science and technology at the University of King's College, Halifax, and is currently Dibner Research Fellow in the History of Science and Technology at The Huntington Library in San Marino, California. This essay is adapted from a chapter of a book he is writing on the relationship between Newton's science and his religion.*

Newton was a believer; more specifically, he believed in the literal and inevitable fulfillment of the prophecies of the book of Revelation, and of all the other biblical prophecies, including the return of the Jews to Israel. So did Locke. Few documents from this period more thoroughly subvert our conventional images of Locke and Newton as unflickering beacons of the Enlightenment than this obscure handwritten chart.

This is not to deny that Lockean and Newtonian ideas are closely bound up with the thought of the Age of Reason. It is just that the relationships between these two thinkers and the Enlightenment—particularly the French, rationalistic variants—are complicated, multilayered, and all too often distorted in favor of secularizing readings that shun the profoundly religious and biblical impulses in their thought. If an apocalyptic chart strikes us as an unexpected artifact to emerge from the decade-and-a-half friendship between Locke and Newton, celebrated respectively as philosopher and physicist, it is probably because they have for too long been



Scheme of the book of Revelation that Isaac Newton gave to John Locke (1691). The arrow of time moves from top to bottom. (For an enlarged view, see TheNewAtlantis.com.)

viewed through the lens of the Enlightenment from the eighteenth century to the present. Newton, especially, has for many years, and to a large extent even today, been seen as a paragon of modernity who represents humanity's supposed victory over the superstitions of antiquity.

But several decades of scholarship, along with some propitious twists of fate, have undone the Enlightenment interpretation of Newton. Unquestionably, the single most important cause of its demise is the astonishing evidence provided in Newton's vast unpublished theological, alchemical, and personal papers. By the 1960s—an iconoclastic era in the academy as well as in society—many of these previously inaccessible manuscripts fortuitously became available and led to the first significant wave of revisionist publications based on them. Revolution was in the air, and the disciplines of history and philosophy of science were no exceptions. In 1962, Thomas Kuhn published his epochal book *The Structure of Scientific Revolutions*, in which he argued that radical changes in our scientific understanding (his famous "paradigm shifts") could happen on other than rational grounds. Scholars were becoming more receptive to the non-scientific contexts of science—be they political, social, cultural, or religious—that were thought to motivate and shape scientific inquiry. These were heady times.

The changes in the 1960s were dramatic not only for the history and philosophy of science, but for science itself. At the time, James Lighthill held the same position that Newton once did as Lucasian Professor of Mathematics at Cambridge. When some years later, in a 1986 paper, Lighthill (by then Sir James) reflected on the shifting currents of the 1960s, he offered a formal apology on behalf of physicists for misleading the public about Newton's physics: "We collectively wish to apologize for having misled the general educated public by spreading ideas about the determinism of systems satisfying Newton's laws of motion that, after 1960, were to be proved incorrect." Lighthill was referring to the recent understanding of chaotic features of these systems, and explained that it was mainly the work of eighteenth-century mathematicians and physicists, such as Pierre-Simon Laplace, that projected onto Newton the belief in a strictly determined, mechanical cosmos.

Among the first to attack this false view of Newton was a young historian of science named David Kubrin, who in 1967 published his revolutionary paper "Newton and the Cyclical Cosmos" in the *Journal of the History of Ideas*. Kubrin's paper did much to overturn the old and cherished image of Newton the rationalist architect of the clockwork universe. The radical nature of the paper consisted not in its argument that Newton believed in

a cosmos over which God is sovereign, for by the 1960s this was known well enough to scholars. Instead, it consisted in the evidence Kubrin provided for Newton's conception of an explicitly *dynamic* cosmos—one that worked quite unlike a perfect mechanism and was instead subject to dramatic change—and its association with, of all things, biblical prophecy. Partway into the paper, Kubrin revealed his purpose:

> It is a commonplace that the Newtonian world-picture consisted of a cosmos which since its Creation *ex nihilo*, had remained substantially the same through the course of time, changing, if at all, only insignificantly. It is, however, a commonplace well worth challenging.

And challenge it he did, in good measure. Kubrin marshaled an impressive array of primary sources to show that "Newton declared, in the 1706 Latin *Opticks*, that the world by itself tended to dissolution, and consequently needed periodic reformation by the Creator." Newton's statement was part of a new query he had added to the end of this book that had first been published in English in 1704. In the words of the 1718 English edition, the world could not have originated "out of a Chaos by the mere Laws of Nature," and although "it may continue by those Laws for many Ages," over time "some inconsiderable Irregularities…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." Kubrin went on to explain—confounding then-common conceptions both of Newton and of the Scientific Revolution—how Newton came to believe that the cosmos tended to decline over long periods of time and that God used the agency of comets to "renew the amount of motion and the regularity of the motions of the heavenly bodies," as the cosmos experienced a "continual cyclical recreation." Along the way, Kubrin also discussed Newton's interest in ethereal spirits and his engagement with prophetic and millenarian thought.

Now, almost a half-century since Kubrin's account, we can update it based on additional manuscript evidence not available in the 1960s, including one document that only resurfaced in 2004. These materials not only support Kubrin's finding that Newton believed in a dynamic (changing) rather than static (unchanging) cosmos, but also suggest that the points of contact between Newton's cosmological views and his understanding of biblical prophecy are even more numerous and more profound than previously thought. To be sure, there are other possible sources besides the Bible for Newton's ideas of cosmic dynamism and decline, such as the writings of the ancient Greek poet Hesiod and the Epicurean philosopher

Lucretius (both of which we know Newton had read), or the alchemical tradition, with its own dynamic views of nature. But given Newton's decades-long engagement with biblical prophecy and his massive output of writings about it, not to mention biblical prophecy's concern with the future of the cosmos, I will argue that (beyond his physics) it is principally to the ancient Hebrews that he owes his views of cosmic change.

I will also suggest that an arrow of time—pointing in one direction and toward a particular goal—is the dominant principle governing Newton's understanding of both prophecy and cosmic change (although I nevertheless affirm Kubrin's insight that there are cyclical elements in Newton's cosmos as well). This arrow of time is often degenerative, corruptive, and, if the reader will excuse a bald anachronism, entropic, even if it is ultimately progressive. In sum, Newton's universe winds down, but God also renews it and ensures that it is going somewhere. The analogy of the clockwork universe so often applied to Newton in popular science publications, some of them even written by scientists and scholars, turns out to be wholly unfitting for his biblically informed cosmology.

Prophecy and the *Principia*

At first glance, it may seem that Newton's research into biblical prophecy had nothing to do with his science. After all, what could be more unlike mathematical physics than the book of Revelation? For the non-religious especially, the Apocalypse signifies a superseded age of faith, whereas the *Principia*, Newton's 1687 magnum opus, holds a place of honor in the canon of secularism and points forward to modernity. But instead of imposing modern (and specifically secular) distinctions on our study of Newton, we must ask how Newton himself saw the world. The most important resource for answering this question is the massive collection of his papers left unpublished at his death.

In September 1940, Albert Einstein sent a letter to his friend Abraham Yahuda, who had acquired a number of Newton's manuscripts on theology (which are now in Israel). Einstein, writing in German, commented that in Newton's unpublished writings on the Bible "we have a variety of sketches and ongoing changes that give us a most interesting look into the mental laboratory of this unique thinker." The words translated as "mental laboratory," *geistige Werkstatt*, can also be rendered "spiritual workshop." Whatever Einstein meant, both senses may apply. The ambiguity of Einstein's description raises an important question: Could Newton's efforts at interpreting the Bible before, during, and after he composed the

first edition of the *Principia* have had an impact on the book's contents of natural philosophy—its physics, astronomy, and cosmology? It may never be possible to answer such a question with clarity and certainty, since it involves the inner workings of a mind from three centuries ago. But the manuscript evidence is suggestive at the very least.

What examples would qualify as creative interplay between Newton's study of prophecy and his great *Principia*? Some of the "Rules for interpreting the words & language in Scripture" he devised for his early treatise on the Apocalypse bear at least a superficial resemblance to the four "Rules of Reasoning in Philosophy" that he had developed through the three editions of the *Principia*. Newton stresses the need for parsimony, both in the interpretation of Scripture and in natural philosophy. For example, the ninth rule of biblical interpretation is, "To choose those constructions which without straining reduce things to the greatest simplicity," while the first rule of reasoning in philosophy reads, "*No more causes of natural things should be admitted than are both true and sufficient to explain their phenomena.*"

Now, parsimony, or Ockham's Razor, as it is commonly known, is of course a *leitmotif* in the history of science and Western thought more generally, so perhaps we should not read too much into this parallel. But the rules for interpreting Scripture also offer us better evidence for a connection between Newton's natural philosophy and his interpretation of prophecy. This is how Newton explains the rule of biblical interpretation just mentioned, where he compares simplicity in understanding nature with simplicity in interpreting prophetic visions:

> Truth is ever to be found in simplicity, & not in the multiplicity & confusion of things. As the world, which to the naked eye exhibits the greatest variety of objects, appears very simple in its internall constitution when surveyed by a philosophic understanding, & so much the simpler by how much the better it is understood, so it is in these visions. It is the perfection of God's works that they are all done with the greatest simplicity. He is the God of order & not of confusion. And therefore as they that would understand the frame of the world must indeavour to reduce their knowledg to all possible simplicity, so it must be in seeking to understand these visions.

At the time Newton wrote this—perhaps as much as ten years before he began to compose the *Principia*—he evidently believed that an assumption of simplicity should apply to both the interpretation of the book of Scripture and the interpretation of the book of Nature: they are linked because both are revelations of God.

What of the 1680s, when Newton wrote the *Principia*? Given that his prophetic researches continued throughout that decade (and indeed until the end of his life), there would have been opportunities for cross-fertilization at that time. It is noteworthy, therefore, that one important clue to Newton's own thinking about the relationship of prophetic interpretation to his work in physics is found in a somewhat unexpected place: a scholium—an extended explanatory comment—on the definitions near the beginning of the *Principia*. In the first part of this comment Newton discusses the need to distinguish between the absolute and relative in physics, in particular with respect to time, space, place, and motion. The relative refers to how we commonly see and experience them, whereas the absolute is their true, measured, mathematical quantity. Newton urges that the two different ways of speaking—ordinary and mathematical—not be confused. The confusion corrupts mathematics and philosophy, he explains; at the same time, people who "interpret these words as referring to the quantities being measured do violence to the Scriptures."

It is not very obvious in the published *Principia* what Newton meant by this reference to the Bible. But a draft of the same passage written around 1685 helps clarify things. There Newton elaborates that

> common people, who do not know how to abstract their thoughts from their senses, always speak of relative quantities, to the point where it would be absurd for either wise men or even for the Prophets to speak otherwise among them. Whence both the Scriptures and the writings of Theologians are always to be understood of relative quantities, and he would be laboring with a gross prejudice who thence stirred up disputations about the philosophical motions of natural things. [*trans. I. Bernard Cohen*]

A final sentence, although struck through in the manuscript, further reveals Newton's argument: "It's just as if someone should contend that the Moon in the first chapter of Genesis was counted among the two greatest lights not by its apparent, but by its absolute, magnitude." Genesis speaks of the sun and the moon as two great lights. But as an astronomer Newton knew that the moon was not a great light in the heavens in terms of absolute magnitude (indeed, it is not even a light, but only a reflector). For Newton, the description in Genesis is not astronomical, but rather expresses a terrestrial perspective commensurate with the capacities of ordinary people. Understanding that the Bible does not use the absolute language of physics avoids a conflict between science and biblical teaching—a principle for which Galileo is famous but which has in

fact ancient Jewish and Christian origins, as in the Talmudic maxim that the Torah speaks the language of man.

Newton's reflections on the similarities and differences between interpreting Scripture and nature show that he thought of the two as connected in important ways. Making the necessary allowances for their respective kinds of language—relative to human experience, and absolute—we should expect Newton's interpretations of prophecy and his scientific work to have points of contact. As we shall see, they in fact do.

Renewing the Church

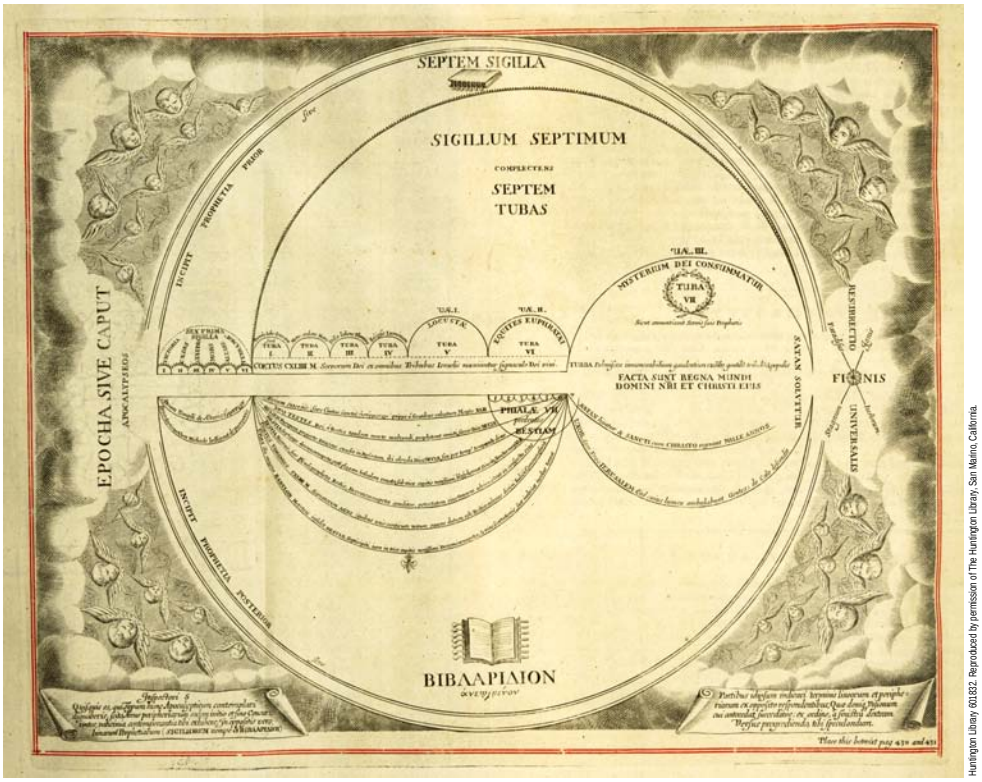
The apocalyptic time chart Newton gave to his friend John Locke provides a helpful starting point for thinking about Newton's views on time and history, distilling key ingredients of Newton's thousands of pages of writings about the book of Revelation. Similar charts were already prominent at the time, particularly those by Joseph Mede (1586–1638) and Henry More (1614–1687), both Fellows of Christ's College, Cambridge. Mede, who in Newton's eyes was a kind of prince of prophetic interpreters, was famous for his book *Clavis Apocalyptica*, which in its 1632 edition included a well-known chart of Revelation (see next page). As for More, who had published several Mede-inspired apocalyptic charts in his lifetime, Newton knew him personally and had discussions (and evidently debates) with him on biblical prophecy. Newton owned the third edition of Mede's *Works* (1672), which includes the *Clavis Apocalyptica* and its chart; he also owned three of More's books on prophecy, one of which contains a chart.

The recent discovery of Newton's personal copy of Mede's *Works* in the collections of the Huntington Library in San Marino, California provides physical testimony to Newton's engagement with his favorite prophetic exegete.* Like most books from Newton's personal library, this volume does not contain annotations; instead, it is filled with Newton's characteristic dog-ears, marking passages of interest to him, well over half of which are to prophetic commentary. This work, more than any other, canonized the historicist interpretation of the book of Revelation, which takes the symbols of the prophecy and puts them on a timeline of

* In preparing this essay for publication, I requested one of The Huntington Library's two copies of the third edition of Mede's *Works*, so that I could order a reproduction of Mede's apocalyptic chart from the same edition Newton owned. When I opened the book and saw the "Musgrave" bookplate—one of several signs that a book comes from Newton's library—I realized to my surprise that this was not merely the same edition Newton owned, but the very copy he owned. (The full story of this discovery can be read in "Newton's Lost Copy of Mede, Revealed" on the Huntington blog "Verso.")

Church and political history from the end of the first century up to and including Christ's literal millennial kingdom and beyond. For Mede, as for Newton after him, Revelation was no mere timeless allegory, but a guide to real historical events.

Perhaps the most distinctive feature of these apocalyptic charts is their linear progression, as if by an arrow of time, to the end of world history. In Mede's chart, time moves from left to right through the book of Revelation; in Newton's, time moves from top to bottom. Like many Protestant interpreters, Newton believed that the book of Revelation foretold the decline of the original, pure form of Christianity into corruption and apostasy, preeminently Roman Catholicism, except that Newton seems to have enlarged this conception to cover all Trinitarian churches. But while the long downward slide of increasing corruption is unmistakable—encompassing the 1,260 days, which are taken to be years, mentioned in



Huntington Library 601832. Reproduced by permission of The Huntington Library, San Marino, California.

Joseph Mede's scheme of the book of Revelation from Isaac Newton's personal copy of Mede's Works *(1672). The arrow of time moves from left to right. (For an enlarged view, see TheNewAtlantis.com.)*

chapters 11 and 12 of Revelation—it is finally punctuated by the intervention of the divine. This providential irruption into human history brings about cataclysmic events in the short term, but peace and stability in the long term. Thus the end of this period sees the universal preaching of the Gospel, the fall of Babylon (the Catholic Church), the first resurrection of the dead, the Day of Judgment, and the beginning of the Millennium. Unlike the amillenarian schemes of Augustine, Luther, and Calvin, which predict no literal thousand-year kingdom on earth subsequent to Christ's return, Newton adopted the premillenarian scheme, in which Christ comes to establish this kingdom on earth. (The prefix in "premillenarian" refers to the time of Christ's coming *vis-à-vis* the Millennium.)

A short fragment Newton wrote on the history of Church apostasy helps provide a discursive backdrop to his chart. When "the Heathen Roman empire" was vanquished by Constantine, the Church took on the temporal wealth and power of pagan Rome; this in turn led to a large incursion of insincere pagan converts into the Church. These converts were "the most hypocritical sort of men," who retained their pagan vices and superstitions and were thus only Christian in "profession." While the Roman Empire remained pagan, the limited attraction of Christianity helped "to keep it from growing corrupt." But once Rome became Christian the Church quickly descended into corruption, with Christians all over the empire becoming debased in morals.

On top of this, Christians abandoned the primitive Gospel for false doctrines and practices such as celibacy, monasticism, the veneration of Mary and the saints, the doctrine of three consubstantial persons of the Trinity, and the deity of the Holy Spirit. Newton concluded: "I hope I have now sufficiently proved that the age from the first Conversion of the Empire to Christianity declined perpetually in manners by the influx of immoral & hypocritical heathens: so as within a few years to become as hypocritical & vitious as our own times at least." Evidently, Newton saw the Church of his own day as no less corrupt and in need of the renewal that would come with the universal preaching of the true Gospel.

Reforming the Cosmos

The Bible's language of decline and renewal sometimes takes on cosmic proportions, especially in the poetic and prophetic books. For instance, in the Psalms the eternity of God is contrasted with the earth and even the heavens, which "shall wax old like a garment" (Psalms 102:26). In Isaiah we read: "And all the host of heaven shall be dissolved, and the heavens

shall be rolled together as a scroll" (Isaiah 34:4)—a passage Newton cited in his prophetic writings. But Isaiah offers the hope of renewal as well: "For, behold, I create new heavens and a new earth" (Isaiah 65:17)—the text echoed again near the end of the book of Revelation. While in the world of the Bible the theme of decline—whether in spiritual, political, or cosmic affairs—is pervasive, the progressive arrow of time always prevails, aiming toward divine redemption and restoration and the New Creation.

Although Newton often treated biblical passages of cosmic decline and renewal as political analogies, it is conceivable that his repeated reading of them over the decades of his biblical studies provided one source for his tendency to think of the cosmos in terms of actual decline and renewal. His view of cosmic change fits the pattern in surprising ways, as is evident from closer inspection of the section of the *Opticks* to which Kubrin drew attention in his paper. In the query that was eventually numbered 31 in later English editions of the *Opticks*, Newton wrote that motion in the cosmos always decreases and is therefore in continual need of conservation and renewal "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." Without 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."

At the same time, Newton explains later in the same text, gravity may give rise to small irregularities that "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."

Newton realized that universal gravity signaled the end of Kepler's stable orbits along perfect ellipses. These regular geometric forms might work in theory and in a two-body system, but not in the real cosmos where many more bodies are involved. This is because the third, fourth, fifth, and other bodies in the gravitational field introduce subtle perturbations into a particular planet's elliptical path (a problem he discussed in Book I of the *Principia*). Newton understood that the mathematics required to describe these complex motions would be impossibly difficult, writing that "it would exceed the force of human wit to consider so many causes of motion at the same time." Crucially, these perturbations are a direct consequence of the force of universal gravity, which Newton himself introduced to physics.

It was this passage about the need for a reformation of the cosmic system that caused the German philosopher Gottfried Wilhelm Leibniz

great dismay and helped to set off his 1715–1716 epistolary debate with the Newtonian Samuel Clarke. Why, Leibniz objected, would a well-designed cosmos need any intervention from God? In his view, a decaying cosmos was a theological barbarism. It entailed that God was like an inept clockmaker, lacking the foresight to design a perfect mechanism and thus having to intervene to repair and tinker with it.

But the ideal of a perfect, clock-like universe was Leibniz's, not Newton's. In his first reply to Leibniz, Clarke rejected the clock emphatically:

> 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…to exclude *Providence* and *God's Government* in reality out of the World.

Despite Clarke's efforts, over time the clockwork universe came to be identified with the Newtonian view, even to this day. This description by eminent astrophysicist Paul Davies in *God and the New Physics* (1983) is typical: "According to Newton's theory, the universe is like a giant clockwork, unwinding along a rigid, predetermined pathway towards an unalterable final state. The course of every atom is presumed to be legislated and decided in advance, laid down since the beginning of time." Yet it was Leibniz who introduced the clockwork analogy, while the Newtonians explicitly rejected it precisely because they found it incompatible with their view of the continuously sovereign God of the Bible (a dynamic about which, to be sure, Leibniz had his own sophisticated views).

One consequence of the false attribution of the clockwork universe to Newton is that his idea of God's interventions in the cosmos is sometimes used as a textbook example of the so-called "God of the gaps." This pejorative expression refers to an intellectually lazy way of ascribing a seemingly unexplainable phenomenon (a gap in our knowledge) to the workings of God. Invoking God in this way is said to be a "science-stopper," as God becomes a substitute for scientific inquiry. To make matters worse, the argument goes, as science continues to advance and fill these gaps in knowledge, God continues to retreat from the cosmos and is left with increasingly little to do.

Of course, Newton is of all people among the last to be guilty of intellectual laziness. More to the point, his God is nothing like the God of the gaps, and there is no evidence that God was ever a "science-stopper" for him. (If anything, his theism helped motivate his work in natural philosophy.) The criticism misunderstands the way Newton saw God acting in the world. According to a common form of the God-of-the-gaps critique,

Newton believed that the cosmos is a wound-up clock that normally functions autonomously following natural laws (as in deism), and since he supposedly could not find a natural explanation for the clock's periodic adjustments—which he presumed to be necessary to make up for its slight and increasing irregularities—he could only explain them in terms of supernatural intervention. To the contrary, Newton was no part-time deist and instead believed (as he put it in a draft text related to the *Principia*) that God through his Providence both "made and governs the world." Clarke elaborated on this same position in his reply to Leibniz, writing that God "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*."

Unlike the God-of-the-gaps way of thinking, Newton did not believe that the cause of a given phenomenon is either natural or supernatural. God is the "first cause," but he still uses the physical world to act on the physical world—whether it be prophets in Israel or comets in the cosmos. So even though for Newton the universe would collapse without God's Providence, and God is behind its motions, the physical world is all along subject to laws and open to mathematical description.

Newton's language of cosmic decline and renewal has religious overtones that help to show that he viewed the entire cosmos as under God's continual governance. In the Latin edition of the *Opticks*, he used the phrase *manum emendatricem* ("amending hand"), which suggests direct, divine intervention. In a subsequent English edition, he chose the word "Reformation," noteworthy because of that word's association with religious renewal. It is in fact likely that Newton considered this language for the renewal of the cosmos around the same time that he composed a theological manuscript discussing religious reformations. One of the central claims of this manuscript, entitled "Irenicum," is that the original religion—consisting of the two greatest commandments as outlined by Christ: loving God and loving one's neighbor—was the pure monotheism practiced by Noah and his family, and that over time it was corrupted. Newton repeatedly describes God's interventions to restore this religion as "reformations." Moses "reformed the Israelites." Likewise, the prophets and then Christ reformed the true religion, and now that "the Gentiles have corrupted themselves we may expect that God in due time will make a new reformation." Whenever mankind has deviated from the true religion, "God has made a reformation." Man corrupts and God restores. The pattern is one of a consistent tendency of religion toward degradation and

the constant need for God to set it back on course via faithful prophets and religious reformations—very much like the cosmos that because of its inherent irregularities requires occasional reformations of its own. The story of human religion and the story of the dynamic cosmos share similar plotlines. For Newton, the same Providence seamlessly sustains both humanity and the cosmos and, when need be, sets them back on course.

Comet Apocalypse

It is possible that one of the main reasons the clockwork image of the universe is still attributed to Newton is that his physics in the *Principia* is so thoroughly mathematical. But a closer look at the evolution of the book shows once again just how inadequate that image really is.

Among the Cambridge University Library's large collection of eight hundred folios of draft papers for all three editions of the *Principia* is a sheet containing material on comets from the first edition (Book Three, Proposition XLI). On this sheet, Newton observes that "the vapors which arise from the sun, fixed stars, and tails of Comets seem to be condensed in the Planets," where they are turned into all organic matter, from water and dirt to vegetation and animals. "Thus comes about the perpetual interchange of all things. . . ." Alchemical notions seem here to inform Newton's dynamic view of nature and a cosmos that plays a direct and active part in the life cycles on earth. (The connection to alchemy is perhaps even more evident in the *Principia*'s 1713 edition, which adds in a similar comment that the cosmic vapors, after turning to water and "humid spirits" are transformed "by a slow heat" into the various substances in the earth.) In contrast to these busy changes, God "alone remains immutable," and has arranged the cosmos in such a way that despite its dynamic nature it is stable, for instance "by removing the fixed stars to convenient distances lest they fall into one another," or by having the planets move around the same center, on the same plane, and in the same direction.

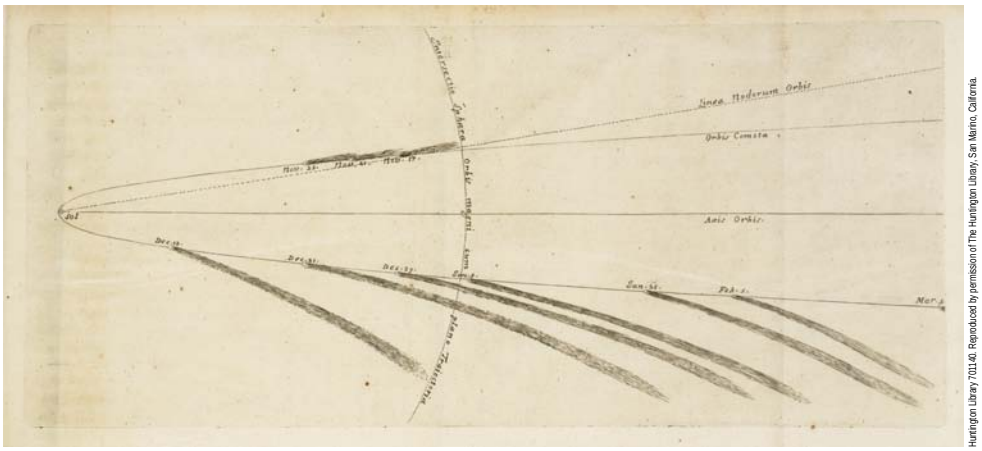
The 1713 edition of the *Principia* contained even more material on the dynamic cosmos not included in the first. Newton reasons (in Book Three, Proposition XLII) that because of the large number of comets, their tremendous distance from the sun at their farthest points from it, and the great length of time spent away from the sun, "they should be disturbed somewhat by their gravities toward one another," resulting in alterations in the shape and periods of their orbits. About the comet of 1680 (which Newton personally observed with his telescope) and its extremely close approach to the sun, Newton writes that the sun's gravitational force sped

up the comet when it neared the sun, whose atmosphere then slowed down the comet, drawing the two bodies slightly closer together. (This also shows that friction, not just gravity, contributes to his dynamic universe.) Newton imagined that the comet, in repeating this pattern, "approaching closer to the sun in every revolution . . . will at length fall into the body of the sun." (An engraving from the first edition of the *Principia* showing the comet of 1680 can be seen below.) Newton continues that, when the comet is farthest away from the sun,

> when it moves most slowly, the comet can sometimes be slowed down by the attraction of other comets and as a result fall into the sun. So also fixed stars, which are exhausted bit by bit in the exhalation of light and vapors, can be renewed by comets falling into them and then, kindled by their new nourishment, can be taken for new stars.

Newton's so-called clockwork universe is hardly timeless, regular, and machine-like; instead, it acts more like an organism that is subject to ongoing growth, decay, and renewal.

Newton also addressed this theme in his famous General Scholium appended to the end of the 1713 and 1726 editions of the *Principia*. In that pithy text, Newton discussed, among other things, the system of planets and comets, claiming that the combination of planets moving in the same direction in a near plane together with the free and extremely eccentric



Huntington Library 70146. Reproduced by permission of The Huntington Library, San Marino, California.

Engraving showing the comet of 1680 from Isaac Newton's Principia *(1687). The comet moves along the solid orbital line from the top right around the sun in the far left to the bottom right. The broad strokes represent the comet's tail as observed by Newton and others on the dates marked along the orbit, from November 1680 to March 1681. (For an enlarged view, see TheNewAtlantis.com.)*

orbits of the comets could not have had "their origin in mechanical causes." (By this Newton seems to have meant *purely* mechanical causes—mere contact motion—without the agency of God.)

Then follows Newton's articulation of the design argument, which also affirms the unity of the cosmos:

> 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. And if the fixed stars are the centers of similar systems, they will all be constructed according to a similar design and subject to the dominion of *One*, especially since the light of the fixed stars is of the same nature as the light of the sun, and all the systems send light into all the others.

In the 1726 edition, Newton added a new sentence immediately after this: "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." (This is similar to what some today call the fine-tuning of the universe.) The implication, again, is that gravity can be a destabilizing force. (An annotation in Newton's own copy of the 1713 edition shows that the sentence he had originally considered adding was the even more theologically charged statement that "the systems of the fixed stars would, through their gravity, gradually fall on each other, were they not carried back by the counsel of the supreme Being.")

The instability of the cosmos also implies for Newton that the earth is not eternal. A manuscript fragment on the corruption of Christianity—sold in 1936, when the bulk of Newton's unpublished writings were put up for auction in London, and reappearing at a 2004 auction in New York—includes a comment that is largely struck through but that reveals a significant train of thought. If one considers, Newton writes, the evidently short history of mankind (judging by the inventions that have survived), the constantly changing substances in the earth and water, and the fact that "the orbs of the Planets & Comets are unstable, & that new stars appear & old ones disappeare: he will see reason to beleive that the several species of living creatures in this earth were not eternal, that the globe of this earth & sea was not eternal" and that we ought therefore to be thankful to God for our existence and sustenance.

Most of these ideas about an unstable cosmos—constantly and at times violently changing—never saw the light of day in Newton's lifetime, or for a long time afterward. One such testimony now publicly available that provides further illumination is the record of a conversation he had in his home

just two years before his death with his nephew-in-law John Conduitt. Through judicious questioning, Conduitt was able to pry from Newton some of his personal thoughts about the past and future of the earth and its solar system. Conduitt, in his account of their talk, emphasized that Newton offered only his conjecture ("he would affirm nothing"). Newton explained that, presumably in the earth's distant past, "there was a sort of revolution in the heavenly bodies," when the emission of the sun's vapors and light formed a body that gradually grew into a planet by attracting matter from other planets and then grew even bigger into a comet, "which after certain revolutions by coming nearer & nearer the sun had all its volatile parts condensed & became a matter fit to recruit & replenish the sun (which must waste by the constant heat & light it emitted)." The comet of 1680 would probably someday fall into the sun the same way, heating the sun up so much that the earth would be burned (Newton seems to have meant its surface only), causing the death of all the animals. Newton also suggested that there were "intelligent beings superior to us who superintended these revolutions of the heavenly bodies by the direction of the supreme being."

When Conduitt pressed Newton on how the earth could or would be repopulated with humans after such a cataclysm, Newton answered "that required the power of a creator." Conduitt pressed even further, asking why he would not make these ideas public simply as conjectures. Newton replied, "I do not deal in conjectures." Conduitt was nothing if not persistent, and, continuing to push Newton, asked about the comet of 1680 and the timing of its appearances, when Newton reached for a copy of the *Principia* on a nearby table, opened it up, and showed him the account of its past appearances. Conduitt, for his part, pointed out the passage where Newton described that comet falling into the sun, and the fixed stars being replenished by comets, and asked "why he would not own as freely what he thought of the sun as well as what he thought of the fixed stars." Newton's memorable reaction was, "that concerned us more, & laughing added he had said enough for people to know his meaning." Blessed as we are today with access to Newton's private papers, we are not limited to the published text of his great scientific work and thus no longer have to guess at his meaning—its religious aspects, or, more broadly, the theological dimensions of Newton's cosmos.

Newton in Motion

The relationship between Newton's work on astronomy, cosmology, and physics on the one hand, and his private manuscripts on history, theology,

and prophecy on the other, reveals a number of distinctive features that ought to challenge the textbook version of Newton still common today. The impression that Newton believed in a purely mechanical and thoroughly mathematical universe is misplaced. Newton emphatically rejected the clockwork universe that is generally associated with him and that is often contrasted with thermodynamic and entropic notions of the cosmos that arose in the nineteenth century. A clockwork universe arguably does not require the constant dominion of God, and, what is more, is perhaps (at least conceptually) a *challenge* to the dominion of God. Yet God's constant involvement in the cosmos was the very thing that Newton desired to uphold, committed as he was to the Scripture's view of Providence.

Nor did Newton advocate an unchanging, static universe. Instead, he recognized that gravity could be a destabilizing as well as a stabilizing force: gravitational forces lead to an accumulation of disturbances over time, such that the cosmos can be said to follow a path of internal development, a unidirectional process in time. The trajectory toward decline has its remedy in the God of dominion, who reforms and adjusts to keep the cosmos orderly, and who recreates when the time comes for a new heaven and a new earth. Newton's cosmos is not deterministic in the secular and materialistic senses often applied to him; nevertheless, its future is ultimately guided by divine action.

Similarly, Newton's view of human history is characterized by profound and often dramatic changes following a course with a God-ordained end. Humanity, civilizations, and religion tend to fall from order to disorder and from true religion to apostasy, as people are unable to sustain the purity of loving neighbor and loving God. Over time, religion inevitably becomes corrupt. While there may be small repeating cycles of rising and falling, the unidirectional arrow of salvation history remains dominant. Although both the human sphere and the cosmos are inherently unstable, both are also under the continuous dominion and sovereignty of God and thus remain dependent on him (perhaps designedly so).

Newton provides a rich case study of the relationship between science and religion in the early era of modern science. Some students of his life and work might want to see a "science-first" principle, in which Newton's science shapes his religion, whereas others might want to contend for a "religion-first" principle, in which Newton's religion guides his science. No doubt there are examples of both. But the truth of the matter is, like his cosmos, much more complex than one might at first suspect. In Newton's intellectual universe, physics and prophecy, together with other disciplines, move much like planets in mutually reinforcing orbits. In

some way probably too difficult to calculate, what we see here is a kind of harmonic resonance and subtle feedback relationship between Newton's observations of the cosmos and his study of the Apocalypse.

But even if the relation between Newton's prophetic and natural philosophical thought cannot be defined with precision, it is clear that the two do not merely share many similarities. For Newton, the history and future of the cosmos are contained within the biblical timeframe from Genesis to Revelation: God created the earth, sustains it, renews it, and ultimately makes all things new. Although Newton's engagement with biblical prophecy only played a minor role in the development and structure of his *Principia*, understanding his writings on prophecy can help illuminate not only the book's historical context but also its content. Whatever a modern might think of this interaction between putatively separate disciplines, it made sense to Newton precisely because he ultimately believed in the unity of reality—and that all reality, whether of the cosmos and its future or of Scripture and the future it portends, is God's, created by his boundless power and sustained by his sovereign will.