WHEN SCIENCE & CHRISTIANITY MEET

Edited by

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To Susan E. Abrams, loyal friend, editor par excellence, and indefatigable supporter of scholarship on the history of science.

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cal debate about Noah's Ark concerned the adequacy of its size, and yet at almost the very moment when this debate appeared to be resolved through a combination of biblical interpretation and practical knowledge of animals, seafarers and naturalists arrived in Europe bearing large burdens of strange beasts, birds, and plants that also had to be squeezed on board. At broadly the same time, natural philosophers attempted to understand fossil remains and their place in the story of the Deluge. They puzzled over the definition of fossils as organic remains. They tried to assemble enough water to cover the whole earth; and it is not surprising that they found it necessary to reduce the size of their floods, first to the inhabited world and then to the Bible lands alone. When this process of ad hoc reinterpretation of the biblical text was added to uncertainties arising from close textual examination of the Scriptures, widespread doctrinal difficulties about the theological status of preadamite man, and growing schism between Catholic and Protestant, the historical accuracy of the traditional account was seriously threatened. The Ark as a real historical event was for the most part discarded by the natural philosophers of the eighteenth century, although the revelatory, allegorical, and metaphorical meanings of Noah's story remained secure.

But as this case history reveals, empirical investigations into the Bible story also produced many significant results. The controversies arising from speculations about the meaning of fossils and the geographical extent of the Flood brought new ideas about the age of the earth and the prehistory of mankind into the open. These were set within a devout religious context but were flexible in their interpretation of ancient writings and chronologies. The attempt to explain how animals arrived in the New World and how Noah's children repopulated the earth stimulated the study of indigenous societies and early human migrations. The search for appropriate sources of water led to distinctive observations about comets, earthquakes, rainfall, and sedimentary strata.

As time passed, however, these careful investigations and explanations created an increasing number of other problems. By pursuing their research with such energy, natural philosophers found themselves disproving what the sacred books said was true. In a way, the biblical Ark was a victim of its own success. By the middle of the nineteenth century men like Charles Darwin and Charles Lyell ridiculed the whole idea. In retrospect, European naturalists had come to accept that the story of the Ark could be understood on two levels, the historical (which they mostly rejected), and the allegorical or religious (which many continued to value). Foundational legends such as this one concerning the Ark can obviously survive even the destruction of the evidence that formerly established their existence.

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Genesis and Geology Revisited: The Order of Nature and the Nature of Order in Nineteenth-Century Britain

Mott T. Greene

Imagine this. It is the year 1821 and you are thirty-six years old. You are a graduate of Oxford University, and you hold the first faculty position in geology (ever) in that university—a position created especially for you. You are also in holy orders, having taken ordination as an Anglican priest at the age of twenty-four, soon after your graduation. (This was not a surprising step since you come from a long line and a large family of Anglican clergymen.) You are a brilliant lecturer and an excellent writer, widely traveled in Britain and on the Continent, and you are acquainted with every great geologist in Europe. There is more: you have just made a discovery, a fantastic discovery, in a cave in Yorkshire. This discovery is going to make you the leading scientist of your generation. It will make students and faculty jostle for seats in your lecture hall. It will make you a best-selling author and the subject of not only newspaper and magazine profiles but long articles in learned journals. It will lead to prizes, offices, money, honors, and fame.

You are already well known (though not quite famous) for a little book called *Vindiciae Geologicae*, which was also the title of your inaugural address, given just two years ago when you assumed your faculty position at Oxford.[1] This little book contains your plan and pledge to "vindicate" the study of geology at Oxford by dedicating geology to the greater glory of God and by showing that a wide variety of geological phenomena visible on the surface of the English

countryside are the remains of the great biblical Deluge, Noah's Flood. You are thus the author of the "diluvial theory" and the founder of modern "Flood geology."

However, you have a problem. Your fantastic discovery in the Yorkshire cave, if you pursue it, is going to undo your diluvial theory, at least in part. It will show that the biblical Deluge is *not* responsible for a great many phenomena attributed to it, and it will show that diluvial geology is *not*, in spite of what you have just written and promised, a sufficiently broad focus for geological theory, nor a very useful means for organizing geological observations. Your discovery is certain to appall and enrage biblical realists (the correct designation for what are often called biblical literalists), including many faculty colleagues who praised your recent book. Finally, you will not easily escape the charge that you are contradicting the account of the Creation given in the Book of Genesis, and therefore some will perhaps say that you are impious, or ungodly, or even an apostate. What are you going to do?

The appeal to principles is difficult. You are absolutely committed to religious truth and absolutely committed to scientific truth. In your previous experience these truths have always been mutually reinforcing, but now they stand opposed. Both are real and both worthy; how can you reconcile them? Your choice is not a struggle of right against wrong, but a struggle of right against right, in which no course of action will easily satisfy all your commitments. The question is not one of advantage and opportunity, but of conscience, and here lies a serious difficulty: you (the young professor of geology) discover almost at once that you have not one, but *two* consciences. You have a moral and religious conscience, and you also have a scientific and intellectual conscience, and you must try to satisfy them both. Will you be able to do it?

This was the real-life predicament of the Reverend William Buckland, D.D. (1784–1856), in the year 1821 (fig. 6.1). His dilemma, and the means by which he resolved it, are an important part of the story of the impact of scientific discoveries on religious beliefs in the decades before Darwin. The Reverend Buckland's scientific and spiritual struggles, and those of his contemporaries, have been told a number of times, and are the basis of *Genesis and Geology* by Charles Coulston Gillispie. They are also the basis of *The Great Chain of History: William Buckland and the English School of Geology (1814–1849)* by Nicolaas Rupke.[2] Gillispie and Rupke explored the encounter between revealed religion and geological discovery in the nineteenth century because they saw that it had some worthwhile lessons to impart about the relationship of science and belief. Among the issues it raises are the role of expert testimony and authority in religion and in science, the means by which these are established and preserved, the function of common sense in scientific work and religious practice, and how and to what purpose the Bible and the world are to be read.

Figure 6.1. The Reverend William Buckland, professor of geology at Oxford, in 1823. Courtesy of Roderick Gordon and Diana Harman.

The Bones from Kirkdale

In July 1821 a group of quarrymen discovered a small limestone cave near the town of Kirkdale in Yorkshire (a large county in the northeast of England) (fig. 6.2). The cave was littered with bones that they had discarded by spreading them on nearby roads, since their aim was not paleontology but quarrying limestone. A country doctor, passing along the road, noticed the strange sizes and shapes of some of these bones and returned later with several friends to examine them. Together they collected a large number of specimens and sent them off to museums in London and elsewhere to be identified.

Buckland received a large box of these bones in November 1821. Using the method of comparative anatomy so recently and so brilliantly developed by Georges Cuvier in France, Buckland was able to determine that the bones were a mixture of the remains of many creatures, including not only deer, bears, and foxes but elephants, hippopotamuses, rhinoceroses, and hyenas. Elated, Buckland wrote to a friend that it was hard to believe that the bones of so many large animals—animals that could never have lived peaceably together—could have gotten into the cave other than by some common calamity, by which he meant, of course, the great global Deluge at the time of Noah.

When Buckland examined these bones carefully, however, they told him a different story. He began to suspect that what the quarrymen had discovered inside the cave were not flood remains, but the accumulated debris of a long-resident den of hyenas. For one thing, the upper surfaces of the bones lodged in

Figure 6.2. The cave and bones of Kirkdale, Yorkshire. From William Buckland, "Account of an Assemblage of Fossil Teeth and Bones of Elephant, Rhinoceros, Hippopotamus, Bear, Tiger, and Hyaena, and Sixteen other Animals, Discovered in a Cave at Kirkdale, Yorkshire, in the Year 1821," *Philosophical Transactions of the Royal Society of London*, 112 (1822), 171–236, p. 236.

the mineral matter of the cave floor had been polished smooth, a phenomenon known from other animal dens where generations of predators had reclined and walked repeatedly on the bones of their prey animals. For another, the bones of the elephants, rhinoceroses, and hippos (though not of the hyenas) were gnawed and broken. Soon after Buckland made this observation, a traveling menagerie came through Oxford with a captive hyena, and Buckland took the opportunity to offer some large bones to the animal to chew. After getting the bones away (he did not say how) he was able to determine that the puncture marks and grooves in the bones he had offered the live hyena, and the way the bones had been broken by the hyena's jaws, were identical to the punctures, grooves, and fractures on the bones from the cave.[3]

One might think it astonishing that the bones of animals today found only in tropical regions should turn up in the muddy floor of an English cave. Yet the discovery, however exciting, did not astonish. A number of published books in the previous twenty years had already documented beyond question that the fossilized remains of many tropical forms of plants and animals were widely distributed across the landscape of northern Europe. Cuvier had shown that distinct assemblages of such remains could be seen in successive layers of rock in

the region around Paris; he had interpreted these rocks and their contents as a series of successive creations and destructions of the living world, long before the appearance of the first humans.[4]

The absence of any human fossils among the remains kept the notion of "antediluvian worlds," even those containing recognizable and existing species, out of direct conflict with Scripture. Geologists, therefore, had experienced little difficulty convincing a broad spectrum of the scientific and religious establishments in Great Britain to accept such worlds as a distinct possibility, though not all were convinced or ready to be convinced. Yet some enthusiasts looking for geological evidences of the Deluge were happy to suppose that, in these remains, they had evidence of a cataclysm so powerful that it had swept the bodies of tropical animals as far north as England. Others, bent on the same quest by a different path, asserted that the animals had been drowned in place by the Flood, and that England's former tropical climate had been permanently altered by this same giant event. In no case was the Deluge account of the Bible placed in doubt.

Even with the supporting body of evidence from cave deposits and fossil-bearing rocks in Europe, and the increasingly popular idea of antediluvian worlds, the bones represented a real problem for Buckland's own diluvial theory. They were quite clearly not those of animals that had died in some sort of cataclysm, nor had they been swept into the cave. The skeletons (except those of hyenas) were not complete; they appeared to be parts of carcasses only, typically the long bones of the legs. Moreover, since the roof of the Kirkdale cave was intact, one could not argue that the bones had fallen or been swept in through a hole or fissure—something observed at other cave sites in England and on the European continent. These bones from Kirkdale were clearly specimens from an antediluvian world, yet they were not in any sense "flood deposits." They cast doubt on the idea that the contents of many other caves (with intact roofs) were the result of flooding, as had previously been supposed. All this had the makings of a serious setback for the diluvial theory as an organizing principle for geology.

If the bones in the hyena den at Kirkdale were a challenge to the diluvial theory, it is not immediately obvious why this should have created great difficulties for Buckland. He had known of and accepted evidence for the existence of antediluvian worlds for quite some time, as had other geologists before him. James Hutton (1726–97), one of the founders of modern geology, had written thirty years before of "revolutions on the surface of the world" with the replacement of one ordered sequence by another, usually interrupted by some convulsion in between.[5] Cuvier had, only a few years before Buckland's inaugural address at Oxford, published a widely read short work, *Discours sur les revolutions de la globe* (*Discourse on the revolutions of the world*, 1812), in which he had come to the same conclusion as Hutton. Cuvier, however, based his interpretation on detailed paleontological and geological evidence from the region around Paris; even more signif-

icant, he offered a spirited defense of the chronology of Genesis for determining the beginning of human time, though not the beginning of the world.[6]

Buckland's discoveries and conclusions did not force him to change his opinions about the world or about the Bible. He continued to believe in the reality of the Deluge described in the Scriptures and still hoped to find universal geological evidence for it. If the evidence from Kirkdale cave could not be applied to this objective, Buckland had no scientific or theological reservation concerning the notion of a succession of creations before the event told of in Genesis, because these revolutions interfered neither with his sense of divine agency nor with his reading of the text of Genesis.

Buckland's Dilemma

Buckland's dilemma—his crisis if you will—arose instead in deciding how he would now vindicate geology as a legitimate subject for study at Oxford, a university that was principally a theological seminary.[7] If the subject matter of geology turned out to be concerned almost entirely with evidence bearing on matters that had transpired before those described in the Bible, and to consist mostly of a chronology of former worlds, it was not at all clear of what use this material would be to prospective clergymen.

The original promise of Buckland's geology at Oxford had been very attractive: If one could ascribe the broad distribution of superficial gravel and the fossil remains contained in it to the action of the universal Deluge described in the Book of Genesis, Anglican clergy would be provided with powerful support from science for an unending source of homilies concerning God's providential intervention in nature. These homilies could be substantiated by such activities as looking out the window, or plowing one's field, or walking on the shore. The point of diluvial geology was not to provide general support for belief in the Bible by pointing to evidences of divine action in the natural world. No one publicly, and few privately, doubted divine action. To demonstrate God's work was the task of all of natural theology, which had been a robust enterprise for almost two thousand years. Rather, the specific point of discovering evidences for a great flood was the providing of empirical proof, outside Scripture, for God's occasional and providential intervention in the course of Nature, in this instance to punish human wickedness.[8]

The issue at hand was not the Creation of the world, but evidence of God's providential intervention to punish evil—long after the Creation. No man of science writing in England in Buckland's time disbelieved in divine providence as it related to the design and population of the world. Not every one spoke of it, and some remained indifferent to it, but not one repudiated it; indeed, a clear majority expressed enthusiasm about it.[9] Because avowed atheism and public blasphemy were crimes actively prosecuted in England until about 1830, the mere mention of providence cannot be taken as an index of belief. Yet for most writers, belief in divine providence was not only sincerely held but thought to be scientifically well supported by a vast literature containing examples of how the world had been prepared as a fitting abode for life. Even naturalists such as Hutton, who had spoken less of the action of God than of the works of Nature, and Erasmus Darwin, the grandfather of Charles and a speculative thinker often mistakenly called an atheist today, both devoted themselves unceasingly to the documentation of the providential ordering of nature.[10] Buckland's generation, however, worried most about the judicial intervention of God in history, and they sought evidence of it in the natural world.

In spite of a conscientious dilemma concerning his scientific duty on the one hand and his duty to bolster support for scriptural authority on the other, Buckland did not hesitate to publish his geological discoveries about the Kirkdale cave. He accepted without reservation the evidence that this collection of fossils in Kirkdale cave had *not* been produced by some startling catastrophe. The layered accumulation, the broken bones, the teeth marks, the complete skeletons of hyenas amid the partial skeletons of large herbivores all pointed to the hyena-den theory. Working quickly and enthusiastically, he put his scientific results together and presented them before the Royal Society of London during three successive weekly meetings in February 1822.[11] The context in which he placed this work before the national scientific elite apparently had nothing to do with theology, the Bible, or the Deluge. He put his hyena den in the purely empirical context of other caves with other kinds of remains in England and elsewhere, speaking as a scientist to other scientists about distribution of rock, soil, and bone.

The response gratified and relieved Buckland. The lectures to the Royal Society created a scientific sensation of a very enthusiastic and positive sort. Magazines in England, Scotland, Germany, and France reported their contents and conclusions for more than two years.[12] In recognition of the significance of his work the Royal Society in 1822 awarded Buckland the Copley Medal, a prize given annually for the greatest achievement in science that year. Before awarding the medal to Buckland, the society had never given it to a geologist; thus the bestowal of the Copley Medal on him represented a vindication of geology.[13]

From this point, Buckland's geological career took off with astonishing speed. Within a year he was acknowledged as the world's leading expert on cave deposits and on the geology of caves. Contemporaries immediately recognized his research as a milestone in geology and paleontology, which marked the beginning of a new field of science now called paleobiogeography, which recon-

structs the character and geographical distribution of communities of plants and animals in past geological periods.

Buckland's report to the Royal Society of his change of mind regarding the geological meaning of Kirkdale, and of similar caves with intact roofs, satisfied his scientific conscience and allowed him to make great professional strides as well. However, the hard part—addressing the impact of his cave research on his theory of the Deluge and on his plans to vindicate geology at Oxford—remained. He still needed to find some way to reaffirm the truth of Scripture with particular reference to the Flood of Noah and to provide proof, by association, for the historical accuracy of the early chapters of Genesis.

To carry out his religious mandate, he decided to use the same evidence to produce an equally important publication that would add to the evidence for the Deluge, or at least preserve what he had already claimed for it. At the time of his addresses to the Royal Society, Buckland had already begun work on this book, to be titled *Reliquae Diluvianae (Relics of the Deluge)*. He had collected a considerable number of observations concerning the superficial deposits and the topography of England that he took to be confirming evidence of a universal flood covering England in recent geological time, a flood he equated with that mentioned in Genesis. He had intended to expand and supplement these researches for his book. But how could his cave researches and hyena dens fit into this plan? If the dens had not resulted from the Deluge, and even pointed away from the Deluge as an explanation for the cave deposits (till then one of the best geological evidences of the Flood), what good could come from presenting his findings in a book on the "relics of the Deluge"? But how could he leave them out when he was world famous for these researches, and any omission of them in a book on the Deluge would be interpreted as an inability successfully to unite his scientific results with his commitment to scriptural authority?

Buckland had to find some way to bend and shape these results in the service of his former plans. Rupke has plausibly suggested that Buckland had an additional impetus to caution: keeping his job. His salaried position as reader was only four years old, and it would be years more before his finances would become secure. (Only after being made canon of Christ Church in 1825 did he draw a clerical salary.)[14] In any case, Buckland set to work on his book with a new approach that he hoped would allow him to keep his commitments in balance and please both scientists and theologians.

Relics of the Deluge?

Buckland, faced with a pressing need to "vindicate his vindication" of geology and to bolster support for the diluvial remnants of his theory, did not dither. In

the year following his address to the Royal Society he brought out a book under the planned title *Reliquae Diluvianae; or, Observations on the Organic Remains Contained in Caves, Fissures, and Diluvial Gravel, and on Other Geological Phenomena, Attesting to the Action of an Universal Deluge.* The book he produced, however, differed somewhat from his original idea for it, largely because of his attempts to solve the problem of vindicating geology as a subject appropriate for a theological seminary while changing the character and content of that vindication.[15]

Buckland's strategy for preserving his role as a scriptural geologist appeared first in the dedication of *Reliquae Diluvianae* to Shute Barrington, the Anglican bishop of Durham. In his dedication Buckland defended both the idea that geology supplies proofs of the universal Deluge and the idea that such proofs are essential to the defense of the veracity of the Book of Genesis. The latter point, the theological point, continued to put him on the side of biblical realists. The former point, that geology provides evidence of the Deluge, was clearly intended to defend the inclusion of this scientific work in the curriculum at Oxford University.

The text of the book reveals a pattern of argument on which Buckland would increasingly rely in his subsequent writings on the subjects of geology and natural theology. He began the book with an affirmation of the truth of Scripture, but then proceeded to a detailed and purely scientific outline of his researches on specific caves and the results of other scientists' work on similar caves. He distinguished sharply between the geological evidence and the historico-theological conclusions to be drawn from it. He concluded each presentation of geology with the claim that there is, in the Kirkdale cave and in similar venues, a thin top layer of mud that must be the residue of the Flood of Genesis. Although this Flood was no longer a global cataclysm, it served as a worldwide geological marker separating the prehuman history of the earth from the scripturally recorded history of the earth and its repopulation by divine intervention.

Buckland's defense of Genesis gave neither pleasure nor comfort to biblical realists accustomed to reading Scripture as the record of the entire history of the earth and the cosmos. As Rupke has pointed out, in spite of its bold front of defending the Deluge, Buckland's work seriously undermined traditional diluvialism in three ways. First, it drastically reduced the portion of the geological record—whether surface gravel or stratified deposits—that could be ascribed to the action of the Deluge. Second, it reduced the power of the floodwaters to transport such material, or fossil bones, by arguing that the tropical fossils found in the caves had not been swept north from tropical regions thousands of miles away by a cataclysmic inundation and its aftermath. Finally, it undermined the widely held theory that the Deluge had occurred in an alternation of land and sea: the sinking of the continents, and the rising of the sea floor, spilling the ocean waters onto the continents and drowning their resident fauna. This

theory had been popular not only among biblical geologists but with Cuvier himself. Buckland's theory, to the contrary, asserted that the land surface of the hyena dens had been dry both before and after the Deluge.[16]

Yet Buckland's science continued to serve the cause of religion. The Oxford geologist had maintained the complete veracity of the Genesis account to his own satisfaction, while slipping as quietly as possible past the question of what Genesis was an account *of*. On this point there were still difficulties to resolve, and through them we are brought face to face with the salient issue in any attempt to reconcile science and Scripture: not *whether* the two should be reconciled but *how*.

The Reading of Scripture and the History of the World

It would distort the story of Genesis and geology if we assumed that the Bible had always been read in a fixed fashion unless challenged to accommodate some scientific fact. The reading of the Bible has a recorded history as complex and varied as the reading of the world by science, with changes typically occurring independently of scientific research. The Bible has long been read simultaneously in a *literal* and a *figurative* sense. Until about the seventeenth century there had been a strong alliance between a realistic reading of the Bible—at once literal and historical—and a figurative reading that provided a basis for doctrine and a means to unify the book as an instrument of moral instruction. After the Protestant Reformation, however, these two ways of reading the Bible began to diverge and even to stand in opposition to each other. Increasingly, the literal reading of the Bible (what the words say) was separated from the figurative reading of the Bible (how the words form a connected and prophetic history).[17] By the early decades of the nineteenth century, when Buckland was working on his cave studies at Oxford, the question of how to read the Bible had become a lively topic of debate without any reference to science at all.

As biblical scholars wrestled to determine which inspired passages were historical and which were allegorical, apparent differences between the Genesis narrative of the Creation and the geological narrative of Earth history took on heightened significance. It was not just that in Genesis the writing is realistic and compelling, but that God is also close to humans, present, visible, directly and evidently concerned. Buckland and his contemporaries, devoted to maintaining the idea of the providential intervention of God in the present, eagerly sought for evidences to support God's interventions in human affairs at the beginning of things, and they responded critically to evidences that turned attention away from such interventions.[18]

An allied issue in the study and reading of Scripture in the early 1800s, also independent of any scientific influence, was the vexing question of authority over the text of the Bible as a whole. Martin Luther's attempt at reform in the early sixteenth century had quickly accelerated into a revolt against the entire Roman Catholic hierarchy of authority—priests, bishops, cardinals, and the pope—in favor of the "priesthood of all believers." It matters little that Luther himself and the German princes who supported him rapidly reformulated an orthodoxy and commenced a vigorous persecution of all who would not submit to it. The fundamental principle remained alive in spite of attempts to modify it: namely, that the word of God is plain and accessible when read by a believer with an open heart. Thus understanding God's word does not require exegesis or interpretation by an authoritative and trained specialist in order to be made clear; it requires only individual initiative and "common sense," if we may be allowed by this term to indicate merely the ability of the common run of humanity to understand God's will through Scripture without theological guidance or sacramental warrant, which was certainly Luther's ideal.

Long before there was a science of geology, the Scientific Revolution of the seventeenth century had already created a contest between scientific and religious authority in interpreting the world, since it embodied intellectual trends that made it run *exactly counter* to the main movement of the Reformation. Foremost among these was a revolt *against* common sense. It is common sense that we are standing still on an immobile Earth while the Sun, the Moon, and the stars revolve around us. It is common sense that if you shoot an arrow straight up into the air, it must exhaust the force with which you shot it before gravity can take hold of it. Further, if the earth is rotating, it is common sense that the arrow must fall behind you, as you and the earth will have rotated while the arrow was aloft. These commonsense ideas are all wrong, but they are not obviously wrong, and demonstrating that they are wrong took an immense amount of effort, industry, and persuasive power over almost two hundred years. In the end the Scientific Revolution produced a new physics of motion in which empirical experiments, not clear ideas, would carry the day.

By the eighteenth century the court of experience had replaced the cult of common sense within the scientific community. Men of science had increasingly come to regard as true only theories supported by experimental and observational evidence. They felt themselves *morally* bound to relinquish belief in any theory that had been contradicted by empirical evidence—no matter how much one was attached to that theory. Finally, they eschewed appeals to hypothetical arguments that the evidence might be wrong. If one had no evidence, he might still have a right to speak but no longer a right to be heard.

Genesis and Geology

Given the challenge to any pretension of authority over the reading of the Bible and the Protestant impetus toward a literal and commonsense reading of Scripture without the aid of specialist expertise, and given the opposed and equally emphatic rejection of commonsense certainty by science, it would have been remarkable if some sort of controversy about "Genesis and geology" had not broken out soon after the science of geology appeared in the nineteenth century. The debate about Genesis and geology that emerged in Great Britain with renewed strength in the 1820s after the publication of Buckland's book was, however, neither a theological nor a scientific free-for-all. It was, as I suggested, not about supplanting religion with science, or about ignoring science in favor of religion; it was a debate about reconciliation of the two. "Genesis and geology" is not code for religion versus science; it refers instead to constant adjustments in the reading of the Bible and nature in order to keep their relationship harmonious. Although there were exceptions, the tone of debate was generally moderate, in part because of the diffuseness and diversity of opinions on the theological side. Religious authority was further rapidly eroding in the 1810s and 1820s with the emancipation of Catholicism, the repeal of the tests of religious orthodoxy as a condition of government employment, and the explosive growth of dissenting and nonconformist Protestant sects, especially evangelicals. On the scientific side, the debate remained moderate because geology was still somewhat insecure and anxious to be accepted as a real science; it had only a tentative foothold in the universities, and its professional structure of associations and publications was just beginning to develop. It courted the good opinion of the world and wished to present itself in the best light.

In any case, in the early 1820s there rapidly emerged a wide variety of opinions on Buckland's work, which, because it was an outstanding combination of world-class science and devout theological interest, became a sort of test case to see how far the claims of natural theology could be pushed and how much detail it could encompass. It also tested the ability of geologists to harmonize their work with Scripture.

The broad sweep of opinion notwithstanding, the overwhelming response from men of science and clergy alike was positive. Buckland's public change of mind about geology had forced him to revise his reconciliation of geology with Genesis, but it had not brought about a change of heart with regard to religion. He had claimed to find some evidence for the Deluge but not as much as he had hoped. His book was seen to advance geological science and to maintain the alliance of science and belief, not least because it seemed to inform the reading of Scripture with scientific evidence.

Buckland, while reporting his cave geology and finding some evidence for a universal Deluge, managed to make an even bolder claim with regard to the geological sequence of the antediluvian world: he interpreted each creation and subsequent destruction as a sign of God's providential intervention. "We see at once," he wrote, "the proof of an overruling Intelligence continuing to superintend, direct, modify, and control operations of the agents which he originally ordained."[19] In this way Buckland argued that the violent (as he supposed) action of geological agencies—floods, earthquakes, eruptions, and rapid uplift of mountains—were the instruments of God's providence. Geology not only failed to challenge Scripture; it revealed the specific agency of God's continual and providential superintending of the world. This was indeed a "vindication of geology" and a presumptive reason to continue to teach it to prospective clergy. Buckland appeared to have carried the day for natural theology.

This lively interest concerning the relationship between geological and scriptural matters persisted in England throughout the rest of the nineteenth century, with a good deal of jostling and debate. The avid pursuit of natural theology in Britain often astonished continental Europeans. The German geologist C. F. Schoenbein, listening to an address by Buckland, noted that "the English have a peculiar love of regarding nature from a theological point of view, and the celebrated Oxford geologist, as he proved by his last geological work, is no exception to the rule."[20] As Gillispie has observed,

> Ever since Newton, natural theology, if not quite a distinctively British approach to God, had at least been elaborated in far greater detail and with much more enthusiasm in Britain than in other countries. British theologians and scientists, so many of whom rested the proof of the existence and activity of God on physical evidence were, therefore, more distressed than leaders of religious opinion elsewhere when empirical argument began to move, if not away from Him, at least in an irrelevant direction.[21]

In the 1820s geology in Britain had begun to move in a direction largely irrelevant to the biblical narrative, as geologists abandoned theoretical debates about the origin of the earth's surface in favor of detailed fieldwork that reconstructed the history of life on Earth. Amateur natural theologians quickly moved into the intellectual vacuum created by the departure of professional geologists. If the prelates of official science would turn geology away from natural theology, the amateurs would steer it back again and create a scriptural geology of their own, guided by common sense and religious zeal. The controversies that sometimes arose created a rather difficult situation for Buckland and others like him,

who tried to stay out of the line of fire. In this Buckland was largely but not completely successful. As Rupke has pointed out, Buckland's fiercest opponents were not fellow geologists but biblical realists, critical of his backing away from a single identifiable geological stratum associated with Noah's Deluge.[22]

William Buckland and Charles Lyell

Buckland, a popular and inspiring lecturer, taught hundreds of students. Most of the great geologists of the next generation, including those forcing changes in his own work, had been his pupils at Oxford. In addition to geologists in training (a small minority of any class to be sure), his audience included prospective clergymen, lawyers, and doctors, as well as young men simply passing through to an Oxford degree. Among them in the years 1817 and 1818 was a young Scot named Charles Lyell (1797–1875), who sat in on Buckland's lectures in mineralogy and geology while preparing for a career in law. Lyell seems to have been a very good student. While doing fieldwork in the summer and fall of 1817 he solved a problem on the geology of caves that had been posed by Buckland and sent the solution to his professor.[23] Perhaps on the strength of this contribution he was elected to the Geological Society of London at the age of twenty-two. Lyell eventually passed the bar exam, but spent little time in the practice of law compared with the time he spent pursuing his real passion: geology. By 1823 he had been elected secretary of the Geological Society of London and by 1826 he had become a fellow of the Royal Society of London. Such a rapid rise suggests strong patronage from Buckland and others as much as great gifts, but there is no doubt that Lyell was an excellent observer and an even more excellent student and companion of observers greater than himself (fig. 6.3). Like Buckland before him, he rapidly developed a wide international acquaintance, facilitated by travels in Germany, France, Italy, and the United States. Drawn to large philosophical issues concerning geology, he devoted much of his effort to writing review articles and broad surveys, frequently based on the researches of others.

In 1828, returning from one of his many trips abroad, he conceived a plan to write a general introduction to the science of geology, including the principles by which geological structures and processes should be evaluated and understood. Because of the tendency of British geologists to collect individual field reports without fitting them into a larger whole, no English-language geologist had attempted a synthesis for more than a decade. Lyell's conversations with European geologists and his own observations had convinced him that there was no reason to postulate great catastrophes in Earth history, even to explain the most extraordinary dislocations that one saw in mountain ranges and volcanic regions.

Figure 6.3. Sir Charles Lyell, who was knighted in 1848.

Lyell believed that, given enough time, very small incremental changes could have accomplished everything in the geological past. Rather than imagining that the earth had been more violent in the past that at present, he assumed that geological and meteorological causes had proceeded through all time at the same rate and level of intensity as they were occurring at in the England of his own day. As he later put it, "the present is the key to the past"—a lesson he had learned from Buckland, who had given a bone to a hyena to see if the teeth marks matched those on the Kirkdale bones.

In Lyell's geological scheme, as opposed to Buckland's, the mighty forces at play were not titanic and intermittent global convulsions but the coral polyp building up the reef, the raindrop hollowing out stone, a slight elevation or depression in an earthquake, an occasional and modest outpouring of lava. Over time these processes had built the greatest structures on Earth. As Buckland had suggested in his lectures, constant erosion under flowing surface water had caused constant deposition somewhere else—and explained the building up of thick sequences of strata over limitless spans of time. Because Lyell saw the whole history of nature as completely uniform, he accepted the name "uniformitarianism" for his approach.

Lyell's three-volume *Principles of Geology* (1830–33) went through many revi-

sions and became arguably the most influential and widely read book on geology ever written in any language.[24] Although rambling and anecdotal, the book offered a great travelogue through time and space, a kind of geological grand tour written by a superb stylist. It entertained and informed not only fellow naturalists but general readers as well. Most important, it aimed to revise common notions about Genesis. Lyell's travels and conversations and reading had convinced him that many theologians and geologists—including his old teacher Buckland—were misleading the public by suggesting that a literal interpretation (by which he meant a realist interpretation) of the Creation narrative in Genesis remained tenable. Without ever mentioning Genesis, he set about to show that an accurate reading of the geological record disallowed the traditional view.[25] Lyell wanted to establish his uniformitarian scheme as a general framework for geology, providing a narrative structure and plot for the thousands of accumulated but uncoordinated observations of geologists over the previous half century or more.

In scriptural terms we could say that Lyell gave the literal facts and words of geology their own figurative meaning, separate from that of the Bible. He took "literal" geological facts and wove them into a great novel of Earth history, showing an equable and majestically slow course of nature. He melded the idea of providence into the idea of design, treating creation and destruction not as alternating epochs but as parallel and simultaneous incremental processes in a figurative history united by the identity of the kind and rate of change. Lyell headed off direct confrontation with Scripture by specifying that geology itself says nothing of the creation or the end of the world. Both are concealed from us, though with patience we can decipher the history in between. He aimed to free geology from any references to what was then called the "Mosaic" record (a term derived from the belief that Moses had written the first five books of the Bible). Lyell demonstrated that one could, in fact, write the story of the earth without reference to the Bible. Indeed, he treated the whole matter of the Flood in two and a half pages of his third volume, in a brief section titled "Supposed Effects of the Flood." There Lyell allowed wearily that he had "been led with great reluctance into this digression"[26]

Lyell concluded his work with the following testimony:

> In whatever direction we pursue our researches, whether in time or space, we discover everywhere the clear proofs of a Creative Intelligence and of His foresight, wisdom, and power.
>
> As geologists, we learn that it is not only the present condition of the globe that has been suited to the accommodation of myriads of living creatures, but that many former states also have been equally adapted to the organization and habits of prior races of beings. The disposition of the seas, continents, and islands, and the climates have varied; so it appears that the species have been changed, and yet they have all been so modelled, on types analogous to those of existing plants and animals, as to indicate throughout a perfect harmony of design and unity of purpose. To assume that the evidence of the beginning or end of so vast a scheme lies within the reach of our philosophical inquiries, or even of our speculations, appears to us inconsistent with a just estimate of the relations which subsist between the finite powers of man and the attributes of an Infinite and Eternal Being.[27]

Lyell may not have uttered the word "God," but his import is nonetheless clear: geology and theology can be reconciled, though perhaps not within the bounds of geology.

The Bridgewater Treatises

After a number of years of publishing nothing on natural theology, Buckland in 1830 stirred to action. He had been extremely busy in the seven years since the appearance of *Reliquae Diluvianae*. In 1825 he had married Mary Moreland, who became his partner in fieldwork and writing. He joined the governing council of the Royal Society in 1827, remaining active there until 1849. He traveled abroad widely in the later 1820s. He often lectured on religion and science, helped establish a geological museum, and worked with Henry de la Beche (1796–1855), the first director of the Geological Survey of Great Britain.[28] Throughout the 1820s Buckland had participated in spirited debates at the Geological Society of London, of which he had been a founding member.[29]

Lyell provided Buckland with something that every public figure desires: "an enemy to the left." The phrase, borrowed from the politics of the French Revolution, suggests that one's own appearance of holding an extreme view is diminished by the presence of someone ever further out of the mainstream. Buckland had come under severe criticism from theological conservatives for his willingness to modify his views of the extent to which geology confirmed Genesis. Now, in contrast to Lyell, Buckland appeared as a shining beacon of theological orthodoxy.

Buckland employed this opportunity with his habitual resolution and skill, using the space created by Lyell to advance his new thinking about the relation of geology and theology. This all came into public view with the publication of his *Geology and Mineralogy Considered with Reference to Natural Theology* (1836), the sixth

volume in a series of treatises on natural theology commissioned by the Reverend Francis Henry, the earl of Bridgewater.[30] A few years before his death in 1829 the reverend earl had set aside £8,000 (about $650,000 in early twenty-first-century American currency) to be paid to authors who would undertake to show in detail, and with abundant evidence, how the various complexities of the natural world gave evidence of design by an all-knowing and beneficent deity. One whole volume focused on the human hand as a triumph of divine design, another on the adaptation of external nature to the physical condition of man, and so on. They were all written by scholars of the first rank. Peter Roget (1779–1869), the secretary of the Royal Society of London, wrote a volume on animal and vegetable physiology. William Whewell (1794–1866), the Cambridge scholar who coined the term "scientist," contributed a treatise on astronomy and physics. William Prout (1785–1850), the celebrated chemist and physician who had shown to everyone's amazement that the gastric juices of animals contain hydrochloric acid, penned an essay on the natural theology of chemistry and the weather.[31]

Buckland was delighted to be asked, in 1830, to write one of these Bridgewater Treatises. It put him in the company of other opinion leaders in the sciences, paid a generous honorarium, and best of all allowed him to present twenty years of his work in a context that allowed him to assert his fidelity to Christian belief while providing details of the history of the earth that either had no counterpart in Scripture or seemed to contradict the account in Genesis. He set to work in 1832, the same year that he became president of the newly founded British Association for the Advancement of Science, which positioned him perfectly to make an influential statement about the harmonies of science and religion.

Buckland's Bridgewater Treatise, especially the chapter on "The Consistency of Geological Discoveries with Sacred History," focused more on the Creation story in the first chapter of Genesis than on Noah's Deluge. Although he did not use the terms, Buckland had transformed himself from a "destructionist" into a "creationist." No longer did he expect to find evidence for the Deluge in the geological remains of the world, nor did he ask for an ongoing correspondence between Genesis and geology, either in literal fact or figurative continuity. Instead, he offered a new defense of the character of geology and of Scripture. "It is argued unfairly against geology," he wrote, "that because its followers are as yet agreed on no complete and incontrovertible theory of the earth; and because early opinions advanced on imperfect evidence have yielded, in succession, to more extensive discoveries; therefore nothing certain is known upon the whole subject; and that all geological deductions must be crude, unauthentic, and conjectural."[32] Like Isaac Newton, he believed that the changing, self-correcting nature of science made it more, rather than less, trustworthy. "It was assuredly prudent," he continued,

> during the infancy of Geology, in the immature state of those physical sciences which formed its only sure foundation, not to enter upon any comparison of the Mosaic account of creation with the structure of the earth, then almost totally unknown; . . . but the discoveries of the last half century have been so extensive in this department of natural knowledge, that . . . it may therefore be proper, in this part of our inquiry, to consider how far the brief account of creation, contained in the Mosaic narrative, can be shown to accord with those in natural phenomena which will come under consideration in the course of the present essay. . . . I trust it may be shown not only that there is no inconsistency between our interpretation of the phenomena of nature and of the Mosaic narrative, but that the results of geological inquiry throw important light on parts of this history, which are otherwise involved in much obscurity. . . . If in this respect, geology should seem to require some little concession from the literal interpreter of Scripture, it may fairly be held to afford ample compensation for this demand, by the large additions it has made to the evidences of natural religion, in a department where revelation was not designed to give information.
>
> The disappointment of those who look for a detailed account of geological phenomena in the Bible, rests on a gratuitous expectation of finding therein historical information, respecting all the operations of the Creator in times and places with which the human race has no concern; as reasonably might we object that the Mosaic history is imperfect, because it makes no specific mention of the satellites of Jupiter, or the rings of Saturn, as feel disappointment at not finding in it the history of geological phenomena, the details of which may be fit matter for an encyclopedia of science, but are foreign to the objects of a volume intended only to be a guide of religious belief and moral conduct.[33]

Several elements of this passage are worthy of mention. The first is the idea that there are periods and places "with which the human race has no concern." That may sound odd coming from a geologist who studied precisely these times and places, but Buckland was merely stating that the providential and moral order that governs human existence began with the six-day Creation in Genesis, not with the original creation "in the beginning." Second, Buckland maintained that the Bible is not an "encyclopedia" of science or culture but a "guide of religious belief and moral conduct." Thus Lyell and other scientific colleagues who argued that the Mosaic narrative could not be historically true because it is so incomplete were missing the point.

How, in Buckland's opinion, could Genesis and geology be reconciled? His answer was refreshingly clear and straightforward. Buckland had no patience for

attempts at plausible reconciliations based on untested scientific hypotheses. Thus he quickly disposed of two "just so" stories suggested by ill-informed amateur naturalists. The first of these ascribed the formation of all stratified rock to the effects of Noah's Flood. This opinion, Buckland declared, "is irreconcilable with the enormous thickness and almost infinite subdivisions of these strata, and with the numerous and regular successions which they contain of the remains of animals and vegetables, differing more and more widely from existing species—as the strata in which we find them are placed at greater depths."[34] He also dismissed the notion that the strata had somehow been formed at the bottom of the sea during the interval between the creation of humans and Noah's Deluge, and that later, at the time of the Flood, the land and water parts of the earth had changed places. "To this hypothesis also," wrote Buckland, "the facts I shall subsequently advance offer insuperable objections."[35]

Buckland urged a new reading of the Creation story in Genesis in terms both literal and figurative but not realistic—precisely the sort of division then current in purely biblical scholarship. Buckland considered two ways of reconciling the Creation story with the facts of geology, both of which have remained popular among evangelical Christians into the twenty-first century. The first of these, which came to be called the "day-age" hypothesis, held that the six "days" of Creation should be read figuratively as indicating indefinitely long time periods rather than actual twenty-four-hour days. This allowed the inspired narrative to be reconciled with the results of science.

Buckland also considered a second hypothesis, based on the curious gap between Genesis 1:1 and Genesis 1:2. Genesis 1:1 reads, "In the beginning God created the heaven and the earth." The next verse describes the earth as being "without form, and void; and darkness was upon the face of the deep. And the spirit of God moved upon the face of the waters." The origin of the world, described in the first verse, might have occurred long before "God moved upon the face of the waters" and began the six-day creative week associated with Adam and Eve. Sufficient time could have elapsed between these two events to accommodate all of the paleontological evidence geologists had uncovered. This so-called gap view required no altering, stretching, figuring, or massaging of the text. Although Buckland saw no sound objection to interpreting the word "day" as a long period of time, he preferred a literal to a figurative solution: "There will be no necessity for such extension [of a day to an age], in order to reconcile the text of Genesis with physical appearances, if it can be shown that the time indicated by the phenomena of geology may be found in the undefined interval, following the announcement of the first verse."[36]

Buckland made a shrewd choice. The great advantage of the gap theory over the day-age view as a reconciliation of Genesis and geology is that virtually the whole geological history of the earth took place in a space and time about which Scripture is silent and can therefore never be contradicted. Thus, from Buckland's standpoint, science and Scripture were brought into permanent harmony. Working within the framework of a gap between the first two verses of Genesis, Buckland proceeded to develop his geological history of the world as a series of events transpiring on a time scale even Lyell could have accepted, nestled between Genesis 1:1 and Genesis 1:2.

Conclusion

The scientists who debated the relationship between Genesis and geology in nineteenth-century Britain tried in different ways to accommodate their religion and their science. William Buckland, arguably the leading scientist of his day, advocated a close relationship between the exploration of nature and the worship of God. While his version of this relationship changed through time, we should not so qualify our understanding as to miss the essential point that neither he nor most of his fellow geologists saw much in their science that threatened their faith, their morals, or their confidence in Scripture as the revealed word of God. They may have experimented with and altered the means of providing such accommodations, moving from geology as evidence of providential intervention to geology as evidence of providential design, but they remained faithful to both their religion and their science. Their experience showed that science and religion, Genesis and geology, were not inevitably antagonistic and were often mutually reinforcing.

Harvard University Press, 1936), and Charles Raven, *English Naturalists from Neckam to Ray: A Study of the Making of the Modern World* (Cambridge: Cambridge University Press, 1947).

15. See especially John Hedley Brooke, *Science and Religion: Some Historical Perspectives* (Cambridge: Cambridge University Press, 1991).

16. Out of a rich and varied analytical literature, see especially Richard S. Westfall, *Science and Religion in Seventeenth-Century England* (New Haven: Yale University Press, 1958); Margaret C. Jacob, *The Newtonians and the English Revolution, 1689–1720* (Hassocks, Sussex: Harvester Press, 1976); Steven Shapin, *The Scientific Revolution* (Chicago: University of Chicago Press, 1996), which includes a useful bibliographical essay; and Peter Harrison, *The Bible, Protestantism, and the Rise of Natural Science* (Cambridge: Cambridge University Press, 1998).

17. For the individuals discussed here and their views on the age and changing nature of the earth, see Gordon L. Davies, *The Earth in Decay: A History of British Geomorphology, 1578–1878* (London: Macdonald, 1968); Paolo Rossi, *The Dark Abyss of Time: The History of the Earth and the History of Nations from Hooke to Vico*, trans. Lydia G. Cochrane (Chicago: University of Chicago Press, 1984); Stephen Toulmin and June Goodfield, *The Discovery of Time* (New York: Harper and Row, 1965); R. Huggett, *Cataclysms and Earth History: The Development of Diluvialism* (Oxford: Clarendon Press, 1989); Francis Haber, *The Age of the World: Moses to Darwin* (Baltimore: Johns Hopkins University Press, 1959); and Rudwick, *The Meaning of Fossils*.

18. Frans A. Stafleu, *Linnaeus and the Linnaeans: The Spreading of Their Ideas in Systematic Botany, 1735–1789* (Utrecht: Oosthoek, 1971); and Browne, *The Secular Ark*, 27–31.

19. Findlen, *Possessing Nature*; Katie Whitaker, "The Culture of Curiosity," in Jardine, Secord, and Spary, *The Cultures of Natural History*, 75–90; David E. Allen, *The Naturalist in Britain: A Social History* (Harmondsworth: Penguin Books, 1978); and Janet Browne, "A Science of Empire: British Biogeography before Darwin," *Revue d'histoire des sciences*, 42 (1992), 453–75.

20. Rhoda Rappaport, "Geology and Orthodoxy: The Case of Noah's Flood in Eighteenth Century Thought," *British Journal for the History of Science*, 11 (1978), 1–18.

21. Jacques Roger, *The Life Sciences in Eighteenth-Century French Thought*, ed. Keith R. Benson, trans. Robert Ellrich (Stanford: Stanford University Press, 1997). See also the introduction to J. Lyon and P. Sloan, eds., *From Natural History to the History of Nature: Readings from Buffon and His Critics* (Notre Dame: University of Notre Dame Press, 1981).

22. James Larson, "Not without a Plan: Geography and Natural History in the Late Eighteenth Century," *Journal of the History of Biology*, 19 (1986), 447–88.

CHAPTER 6

1. William Buckland, *Vindiciae Geologicae; or, The Connexion of Geology with Religion Explained* (Oxford, 1820).

2. Charles Coulston Gillispie, *Genesis and Geology: A Study in the Relations of Scientific Thought, Natural Theology, and Social Opinion in Great Britain, 1790–1850* (Cambridge: Harvard University Press, 1951); Nicolaas A. Rupke, *The Great Chain of History: William Buckland and the English School of Geology (1814–1849)* (Oxford: Clarendon Press, 1983).

3. Rupke, *Great Chain of History*, 32–33; Gillispie, *Genesis and Geology*, 108. In Gillispie's version Buckland actually acquired the hyena.

4. Mott T. Greene, *Geology in the Nineteenth Century: Changing Views of a Changing World* (Ithaca: Cornell University Press, 1982), 85–87.

5. James Hutton, "On the Theory of the Earth; or, An Investigation of the Laws Observable in the Composition, Dissolution, and Restoration of the Globe," *Transactions of the Royal Society of Edinburgh*, 1 (1788), 209–304.

6. Georges Cuvier, *Recherches sur les ossemens fossiles des quadrupèdes: Discours préliminaire: Discours sur les révolutions de la globe* (Paris, 1812).

7. Rupke, *Great Chain of History*, 51. I agree with Rupke's contention that this was Buckland's real concern.

8. This is the principal argument of Gillispie, *Genesis and Geology*.

9. Ibid., 33.

10. Gordon L. Davies, *The Earth in Decay: A History of British Geomorphology, 1578–1878* (New York: American Elsevier, 1969); Hutton, "On the Theory of the Earth"; Greene, *Geology in the Nineteenth Century*, chap. 1; Erasmus Darwin, *Zoonomia; or, The Laws of Organic Life*, 2 vols. (London, 1794–96).

11. Rupke, *Great Chain of History*; William Buckland, "Account of an Assemblage of Fossil Teeth and Bones of Elephant, Rhinoceros, Hippopotamus, Bear, Tiger, and Hyaena, and Sixteen other Animals, Discovered in a Cave at Kirkdale, Yorkshire, in the Year 1821," *Philosophical Transactions of the Royal Society of London*, 112 (1822), 171–236.

12. Rupke, *Great Chain of History*, 36.

13. Gillispie, *Genesis and Geology*, 108.

14. Rupke, *Great Chain of History*, 51.

15. William Buckland, *Reliquae Diluvianae; or, Observations on the Organic Remains Contained in Caves, Fissures, and Diluvial Gravel, and on Other Geological Phenomena, Attesting to the Action of a Universal Deluge* (London, 1823).

16. Rupke, *Great Chain of History*, 39–41.

17. Hans W. Frei, *The Eclipse of Biblical Narrative* (New Haven: Yale University Press, 1974), chap. 2.

18. Gillispie, *Genesis and Geology*, 226.

19. Buckland, *Vindiciae Geologicae*, 19.

20. Quoted in Gillispie, *Genesis and Geology*, 200.

21. Ibid., 222.

22. Rupke, *Great Chain of History*, 49, 194.

23. Leonard G. Wilson, "Lyell, Charles," in *Dictionary of Scientific Biography*, 8:563–76, esp. 564.

24. Charles Lyell, *Principles of Geology*, 3 vols. (London: John Murray, 1830–33; reprinted in facsimile with an introduction by Martin Rudwick, Chicago: University of Chicago Press, 1990).

25. Ibid., 1:xvii.

26. Ibid., 3:270–72.

27. Ibid., 3:384–85.

28. Walter F. Cannon, "Buckland, William," in *Dictionary of Scientific Biography*, 2:566–71, esp. 567.

29. Greene, *Geology in the Nineteenth Century*, 69ff.

30. William Buckland, *Geology and Mineralogy Considered with Reference to Natural Theology*, 2 vols. (London: William Pickering, 1836).

31. Ibid., 1:x–xii.

32. Ibid., 1:11.

33. Ibid., 1:11–15.

34. Ibid., 1:16.

35. Ibid., 1:17.

36. Ibid., 1:18.

CHAPTER 7

1. L[ouis] A[gassiz], "The Diversity of Origin of the Human Races," *Christian Examiner*, 49 (1850), 110–45; Charles Lyell, *Geological Evidences of the Antiquity of Man* (London: Murray, 1863).

2. On the Protestant response to Darwinism and the timing of the debate in America, see Jon H. Roberts, *Darwinism and the Divine in America: Protestant Intellectuals and Organic Evolution, 1859–1900* (Madison: University of Wisconsin Press, 1988).

3. James Ussher, *Annals of the World Deduced from the Origin of Time* (London, 1658) (translation of *Annales Veteris Testamenti* [London, 1650]), 1. See William R. Brice, "Bishop Ussher, John Lightfoot, and the Age of Creation," *Journal of Geological Education*, 30 (1982), 18–24.

4. See Paolo Rossi, *The Dark Abyss of Time: The History of the Earth and the History of the Nations from Hooke to Vico*, trans. Lydia G. Cochrane (Chicago: University of Chicago Press, 1984), 107–8.

5. See Ronald L. Numbers, *Creation by Natural Law: Laplace's Nebular Hypothesis in American Thought* (Seattle: University of Washington Press, 1977), 88–104; and Numbers, *The Creationists* (New York: Knopf, 1992), xii–xiii, which contains a helpful chart comparing the gap and day-age theories.

6. The complete title of the English translation is *Men Before Adam; or, A Discourse upon the Twelfth, Thirteenth, and Fourteenth Verses of the Fifth Chapter of the Epistle of the Apostle Paul to the Romans, by Which Are Prov'd, That Men Were Created before Adam* (London, 1656). Richard Popkin has written the most on La Peyrère and preadamism. See his "Pre-Adamism in 19th Century American Thought: 'Speculative Biology' and Racism," *Philosophia*, 8 (1978), 205–39, and his biography of La Peyrère, *Isaac La Peyrère (1596–1676): His Life, Work, and Influence* (Leiden: Brill, 1987). See also David N. Livingstone, *The Preadamite Theory and the Marriage of Science and Religion* (Philadelphia: American Philosophical Society, 1992).

7. Thomas Jefferson, *Notes on the State of Virginia* (London, 1787; reprint, Chapel Hill: University of North Carolina Press, 1955), 138.

8. Henry Home, Lord Kames, *Sketches of the History of Man*, 2d ed., 4 vols. (Edinburgh, 1778; reprint. Hildesheim: Georg Olms Verlagsbuchhandlung, 1968), 1:3–84, esp. 76–79.

9. Samuel S. Smith, *An Essay on the Causes of the Variety of Complexion and Figure in the Human Species*, 2d ed. (New York, 1810; reprint, Cambridge: Harvard University Press, 1965), esp. 71–72, 89–90, 155, 184–85. I am grateful to David N. Livingstone for pointing out the political dimension of Smith's work. See also Winthrop D. Jordan's introduction to Smith's *Essay*, xv–xvi.

10. The most complete introduction to the American school of ethnology remains William Stanton, *The Leopard's Spots: Scientific Attitudes toward Race in America, 1815–59* (Chicago: University of Chicago Press, 1960). On geology and astronomy, respectively, see Rodney L. Stiling, "The Diminishing Deluge: Noah's Flood in Nineteenth-Century American Thought," Ph.D. diss., University of Wisconsin-Madison, 1991; and Numbers, *Creation by Natural Law*.

11. Samuel G. Morton, *Crania Americana; or, A Comparative View of the Skulls of Various Aboriginal Nations of North and South America, to Which Is Prefixed an Essay on the Varieties of the Human Species* (Philadelphia and London, 1839), 260. See Stephen Jay Gould, *The Mismeasure of Man* (New York: Norton, 1981), for an exposé of the unconscious racial bias in Morton's work.

12. Morton, *Crania Americana*, 260.

13. Samuel G. Morton, *Crania Ægyptiaca; or, Observations on Egyptian Ethnography, Derived from Anatomy, History and the Monuments* (Philadelphia, 1844), 66.

14. Stanton, *Leopard's Spots*, 146–47.

15. Reginald Horsman, *Josiah Nott of Mobile: Southerner, Physician, and Racial Theorist* (Baton Rouge: Louisiana State University Press, 1987), is the standard biography.

16. *American Journal of the Medical Sciences*, 6 (1843), 252–56. On the census, see Albert Deutsch, "The First U.S. Census of the Insane (1840) and Its Use as Pro-slavery Propaganda," *Bulletin of the History of Medicine*, 15 (1944), 469–82.

17. Stanton, *Leopard's Spots*, 66–72, 113–18.

18. Horsman, *Josiah Nott*, 5–26, 82.

19. Edward Lurie, *Louis Agassiz: A Life in Science* (Chicago: University of Chicago Press, 1960), is the standard biography.

20. Quoted ibid., 261.

21. Gould, *Mismeasure of Man*, 44–45. See also Lurie, *Louis Agassiz*, 256–57; Stanton, *Leopard's Spots*, 104–5.

22. Louis Agassiz, "Geographical Distribution of Animals," *Christian Examiner*, 48 (1850), 184–85.

23. A[gassiz], "Diversity of Origin of the Human Races"; Agassiz, "Contemplations of God in the Kosmos," *Christian Examiner*, 50 (1851), 1–17, quotation on p. 4.

24. Josiah Nott and George Gliddon, *Types of Mankind* (Philadelphia, 1854).

25. John Bachman, *The Doctrine of the Unity of the Human Race Examined on the Principles of Science* (Charleston, 1850). For Stanton's jaundiced view of Bachman, see *Leopard's Spots*, 123–36, 155. Lester D. Stephens, *Science, Race, and Religion in the American South: John Bachman and the Charleston Circle of Naturalists, 1815–1895* (Chapel Hill: University of North Carolina Press, 2000), provides an important corrective to Stanton.

26. Charles Hodge, "An Examination of Some Reasonings against the Unity of Mankind," *Biblical Repository and Princeton Review*, 34 (1862), 435–64; Hodge, "The Unity of Mankind," ibid., 31 (1859), 131; Gould, *Mismeasure of Man*, 54–69. On Hodge and science, see also Ronald L. Numbers, "Charles Hodge and the Beauties and Deformities of Science," in John W. Stewart and James H. Moorhead, eds., *Charles Hodge Revisited: A Critical Appraisal of His Life and Work* (Grand Rapids, Mich.: Eerdmans, 2002), 77–101.

27. Review of *Types of Mankind*, by Josiah Nott and George Gliddon, in *Presbyterian Magazine*, 4 (1854), 289.