Chapter 4. Mistaken in Its Age

The music begins with the big bang of a loud chord but then gets unexpectedly quiet. What follows is oddly static, alternating between loud and soft passages that don't seem related to each other. The music drifts aimlessly in a state of restless indecision. Chord progressions that advance towards a climax fail to reach a final resolution, and short fragmented woodwind melodies bubble up without quite going anywhere.

Then, arising from this musical chaos, a bass voice begins singing a slow and stately declamation of words familiar to everyone who's ever started reading the Bible, even those who never got very far:

> In the beginning God created the Heaven and the Earth. And the earth was 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. And God said, Let there be light: and there was…

At this point, the entire chorus and orchestra explode with pounding tympani and screaming horns in a bright resounding triumphant C-major chord:

> LIGHT!

When Joseph Haydn's oratorio *The Creation* premiered in London on March 28, 1800, the audience burst into spontaneous applause at this sonic celebration.[1]

The light that shines forth in the opening minutes of Haydn's great work refers to more than the literal illumination of the universe. During the 18th century, light had taken on an additional metaphorical meaning as an allusion to the Enlightenment and the pursuit of truth, knowledge, and wisdom. While an oratorio based on the Book of Genesis might not seem in accordance with the more religiously skeptical aspects of the Enlightenment program, in Haydn's hands the Creation story becomes a hymn to the wonders of the natural world, imbued with his joyful and optimistic worldview.[2]

Haydn spent most of his life in his native Austria, but between 1791 and 1795, in his late 50s and early 60s, he braved a long trip that included the treacherous English Channel to make two 18-month visits to England. Despite an unfamiliarity with the English

---

[1] H.C. Robbins Landon, *Haydn: Chronicle and Works, Volume IV: The Years of "The Creation," 1796–1800* (Indiana University Press, 1977), p. 574, quoting Charles Burney from *Memoirs of Doctor Burney*, Volume III (London: Edward Moxon, 1832), https://books.google.com/books?id=Q_h9IprH428C, p. 421.

[2] Mark Berry, "Haydn's *Creation* and Enlightenment Theology," *Austrian History Yearbook* 39 (2008), (http://www.academia.edu/267334/Haydn_s_Creation_and_Enlightenment_Theology), pp. 25–44.

language, these stays were some of the happiest days of his life.[3] Between the 1791 death of Mozart and the emergence of Beethoven, Haydn was the most prominent composer in Europe. The English called him the "Shakespeare of music"[4] and even the "God of musical science."[5] Haydn composed the final dozen of his 104 symphonies for the London audience, he was awarded an honorary Doctor of Music from Oxford, and he developed a pleasant romantic relationship with a widow twenty years his junior named Rebecca Schroeter, who had requested piano lessons from the composer.[6]

In May 1791, Haydn attended a music festival at Westminster Abbey in commemoration of George Frideric Handel, another German-speaking composer who wooed the English. Handel had been dead for three decades, but the English still loved his music. Haydn heard excerpts from ten Handel oratorios and complete versions of *The Messiah* and *Israel in Egypt* performed with big orchestras and choruses, possibly for the first time in his life.[7] Both of these works had been written expressly for the London audience with English libretti.

Hearing Handel's music and experiencing the audience reaction likely gave Haydn the idea to compose a big oratorio of his own on a religious theme. On his return to Vienna after his second stay in England, he had with him an English libretto that had originally been intended for Handel. This libretto was then reworked in both German and English versions by Gottfried van Swieten, a figure who also appears in the careers of Mozart and Beethoven. Haydn took an uncharacteristically long time to compose the music for *The Creation* for he meant it to last.[8]

It is believed that the score for *The Creation* is the first large-scale work of music to be published in a bilingual edition.[9] It was first performed in Vienna in 1798 and 1799, and then in London in 1800 by two competing music organizations within a month of each other. Later in 1800, the Paris premiere took place on Christmas Eve. As the coaches carrying First Consul Napoleon Bonaparte and Joséphine approached the theater, a bomb exploded. Some bystanders were killed and injured, but not the intended target of the assassination attempt, and the performance was delayed only ten minutes.

---

[3] Marion M. Scott, "Haydn in England," *The Musical Quarterly*, Vol. 18, No. 2 (Apr, 1932), pp. 260-273.
[4] David R. Schroeder, *Haydn and the Enlightenment: The Late Symphonies and their Audience* (Oxford University Press, 1990), p. 109.
[5] Karl and Irene Geiringer, *Haydn: A Creative Life in Music*, 3rd edition (University of California Press, 1982), pp. 149.
[6] Geiringer, *Haydn: A Creative Life in Music*, pp. 119–121, 143–144.
[7] Bruce C. MacIntyre, *Haydn: The Creation* (NY: Schirmer Books, 1998), p. 31.
[8] Geiringer, *Haydn: A Creative Life in Music*, p. 158.
[9] http://ks.imslp.info/files/imglnks/usimg/4/41/IMSLP471217-PMLP40341-E93357_etc-1_pdfsam_haydn_skab_1.pdf

Performances in other countries followed: "within two or three years, *The Creation* was to become the most popular large-scale work of its kind in the whole of the civilized world."[10]

The most famous part of *The Creation* remains the Representation of Chaos at the very beginning. Based on surviving sketches, Haydn labored over this section more than any other part of the oratorio. It wasn't easy: The musical language of the classical era stressed order and rationality. It did not lend itself to expressing chaos. Using unresolved chord progressions and melodies, Haydn manages to suggest an unsettling mysterious mistiness in a long-ago time when the strict rules of harmony were still in an undeveloped state.

Following the dramatic appearance of light in *The Creation*, each of the six days is presented first with the passage from Genesis, and then elaborated upon with excerpts from John Milton's epic poem *Paradise Lost* and additional commentary drawn from the book of Psalms. In the English-language version of *The Creation*, the familiar King James translation of the Bible is used, but the Milton is mangled and rendered nearly unrecognizable, perhaps the result of having been translated to German and back to English.

Nevertheless, these texts give Haydn the opportunity to exercise the skills he acquired from almost 50 years of composing. Particularly on the fifth and sixth days, Haydn gives life to the newly created animals: cooing and chirping birds, the murky underwater depths of the great whales, a roaring lion, galloping stags and horses, peacefully grazing cattle, swarming insects, a creeping worm.

In this way, Haydn's *Creation* becomes almost a work of *natural theology*, a musical equivalent of those many books of the era that used evidences from the natural world to establish the existence of God as well as attributes such as power, wisdom, goodness, and benevolence. The most famous of these books is William Paley's *Natural Theology: or, Evidences of the Existence and Attributes of the Deity, Collected from the Appearances of Nature*, published in 1802, just a couple years after *The Creation*. Like Paley, Haydn presents a God who is reflected in the orderly and harmonious assemblage of living things. "Light shone, and order from disorder sprung," wrote Milton;[11] "Now chaos ends, and order fair prevails," sings the archangel Uriel in *The Creation*. The oratorio even includes a paraphrase of the purest exposition of natural theology in the Old Testament: "The heavens declare the glory of God; and the firmament sheweth his handywork." (Psalm 19:1)

Except for a fleeting mention of "hell's spirits," Satan is nowhere to be found in Haydn's version of Creation, and after the sixth day, even God retreats to the background. No metaphorical fruit is forbidden and no transgressions occur. The last half hour is turned over to Adam and Eve, who sing lovely arias and a duet while they glory in this new world and themselves. The oratorio leaves the happy couple in joyful and contented bliss with only a brief allusion to the upcoming stumbles when they are "misled by false conceit." Also

---

[10] Landon, *Haydn: Chronicle and Works*, Vol. IV, p. 325.
[11] *Paradise Lost*, Book 3, line 713.

gracefully avoided are the first couple's banishment from paradise, their two squabbling sons, and later events in Genesis such as the great Deluge that destroys all of humanity except for Noah's extended family.

Haydn's version of Creation is sunny and humanist, overflowing with Enlightenment optimism. Along with the glorious music, this happy glow is what has allowed *The Creation* to continue to appeal to audiences even after two centuries. It is not necessary to believe in the historical accuracy of Genesis to enjoy Haydn's musical adaptation of its story. Even in the year 1800, the London audience would have had a mix of opinions about Genesis: As one historian notes, this was a time when "literal and non-literal interpretations were equally current."[12]

Despite a wavering of belief in Genesis in the late 18th century, natural theology was still pervasive. Paley's book was less of a groundbreaker and more of a summing up of ideas that had long been woven into the texture of Britain's culture and practice of science. The idea that men of science were exploring and revealing God's Creation gave impetus and justification to their work. Natural theology also helped to connect Britain's diverse religious communities. By providing a common rational system of belief, natural theology united all Christian denominations to avoid the conflicts that had plagued the earlier centuries (at least in theory). Historian Margaret Jacob shows how a foundation of natural theology was instrumental in the founding of the Royal Society in 1660,[13] and it remained crucial to the study of nature through the first half of the 19th century, where it was termed by historian Robert M. Young as the "common intellectual context."[14]

Natural theology had always been closely associated with the *design argument* — the idea that the evident design in the natural world implies the existence of a designer. In the 17th century, the study of nature demonstrated a regularity in the workings of the universe that could be described with natural laws, often of a mathematical nature. Natural theology then became concerned with how the Creation was manifested through these laws. Yet, a tension became apparent: An emphasis on natural law tends to force divine providence into the background. As the universe is increasingly shown to be governed by fixed laws, God's perfect creation might seem to run by itself and God's role becomes diminished. The need for miracles and divine intervention implies a flawed creation; yet the absence of miracles suggests a God who no longer cares.

For Paley and many others, natural theology was necessarily complemented by *revealed theology* — the study of scripture. Natural theology provided the proof of God's existence and benevolence, while revelation elaborated on all the aspects of God's plan that can't be derived from nature. Paley never intended *Natural Theology* to be read in isolation. Earlier he had written books about the evidences of Christianity and the writings of St.

---

[12] Ralph O'Connor, *The Earth on Show: Fossils and the Poetics of Popular Science, 1802–1856* (University of Chicago Press, 2007), p. 135, and p. 234ff for an extended discussion.
[13] Margaret C. Jacob, *The Newtonians and the English Revolution, 1689–1720* (Cornell University Press, 1976), p. 37.
[14] Robert M. Young, *Darwin's Metaphor: Nature's Place in Victorian Culture* (Cambridge University Press, 1985), p. 126.

Paul that would guide the reader towards orthodox belief after having been convinced of the existence of God through the demonstrations of natural theology.

Not everyone accepted the necessity of making the big leap from natural theology to revealed theology. Those who did not became deists — people who believed in God but not much else. Deists were often strong advocates of natural theology, which they sometimes called "rational religion," religion that derived solely from logical consideration of the natural world. It was obvious to deists that a Supreme Being created the universe and all living things, but they were often quite skeptical of scripture, apart from sometimes acknowledging Jesus as a moral philosopher of some note.

Beginning in the late 17th century, and continuing through the 18th century, religious controversies erupted over these issues.[15] Deists mocked the scriptures while devout Christians armed themselves against skepticism. One such Christian was the natural philosopher Robert Boyle, who bequeathed funds at his death in 1691 to establish lectures for "proving the Christian Religion, against notorious Infidels, viz Atheists, Theists [a synonym for deists at the time], Pagans, Jews and Mahometans, not descending lower to any Controversies, that are among Christians themselves."[16] This last phrase referred to the need to avoid alienating the numerous Christian sects that had been allowed to flourish following the Glorious Revolution. The Boyle Lectures continued on a fairly regular basis for over 200 years, and then sporadically during the 20th century, and they've even been revived and conducted annually since 2005.

The first Boyle lecturer was Richard Bentley, who spoke on *A Confutation of Atheism*, and he was counseled by Isaac Newton. In 1692, Newton sent Bentley a letter about the theological uses of natural philosophy: "When I wrote my Treatise about our System, I had an Eye upon such Principles as might work with considering Men for the Belief of a Deity, and nothing can rejoice me more than to find it useful for that Purpose."[17] Yet, Newton was never a Boyle lecturer himself, and his own writings on natural theology are scant.

Perhaps Newton's most significant contribution to natural theology is a simple observation about the Solar System in the General Scholium that he added to the very end of the second edition of the *Principia* in 1713:

> The six primary planets revolve about the sun in circles concentric with the sun, with the same direction of motion, and very nearly in the same plane. Ten moons revolve about the earth, Jupiter, and Saturn in concentric circles, with the same direction of motion, very nearly in the planes of the orbits of the planets. And all

---

[15] A good overview is Roland N. Stromberg, *Religious Liberalism in Eighteenth-Century England* (Oxford University Press, 1954).
[16] Andrew Pyle, introduction to *The Boyle Lectures (1692 – 1732)* (University of Bristol, 2000).
[17] *Four Letters from Sir Isaac Newton to Doctor Bentley Containing Some Arguments in Proof of a Deity* (London: R. and J. Dodsley, 1756), p. 1, and numerous other sources, including *Newton's Philosophy of Nature: Selections from his Writings,* ed. H. S. Thayer (New York: Hafner Press, 1953), p. 46.

> these regular motions do not have their origin in mechanical causes, since comets go freely in very eccentric orbits and into all parts of the heavens. [18]

If a physical law mandated that all the planets and moons of the Solar System revolve in the same direction and approximately in the same plane, obviously that law would affect comets as well.

This regularity of the orbits is not the result of a physical law, yet it is essential in preserving the stability of the solar system. The planets move in elliptical orbits, but these ellipses are nearly circular. (Technically, the elliptical orbits have a small *eccentricity*.) If the orbits were more eccentric, or if the orbits were at large angles to each other, their gravitational interaction might cause unpredictable perturbations. Imagine an earth that was plunged into an extreme ice age or hot spell every thousand years: Such a world might never have been able to support the cultural continuity necessary for civilization.

The uniformity in the orbits of the planets and their moons could not have come about by chance, and Newton provides a classic natural theological explanation: "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."[19] Put simply, the planets orbit in the same direction in the same plane because God made them that way. It is a manifestation of God's benevolence.

In the second edition of *Opticks* (1718) Newton repeated the argument and wrote "it's unphilosophical to seek for any other Origin of the World, or to pretend that it might arise out of Chaos by the mere Laws of Nature."[20]

In an age where the pursuit of science was known as natural philosophy, the word *unphilosophical* was an exceptionally strong accusation, encompassing both an inability to perceive natural phenomena and to interpret them correctly.

To some, however, this accusation might be interpreted as a challenge.

The first person to take up Newton's challenge was George-Louis Leclerc, better known by his acquired title the Comte de Buffon. Buffon was a towering figure in natural history. As curator of the Jardin du Roi (the Royal Botanic Gardens) in Paris, Buffon created an extensive research center and studied the whole range of animal, plant, and mineral kingdoms. Beginning in 1749, he began publishing books under the general title *Histoire Naturelle, générale et particulière*. By the time of Buffon's death (and the French Revolution the following year), the series totaled 36 volumes.

---

[18] Isaac Newton, *The Principia: Mathematical Principles of Natural Philosophy*, trans. I. Bernard Cohen and Anne Whitman (University of California Press, 1999), p. 940.
[19] Ibid.
[20] Isaac Newton, *Opticks: Or, a Treatise of the Reflections, Refractions, Inflections and Colours of Light* (London: W. and J. Innys, 1718), https://books.google.com/books?id=TwhbAAAAQAAJ, p. 378. Greenblatt's quotations from *Opticks* appear on pages 376 and 375–6, respectively.

The first volume of *Histoire Naturelle*[21] begins with a preliminary discourse and then a history and theory of the earth. Like Newton, Buffon notes that all the planets revolve around the sun in the same direction and that the orbits are all approximately in the same plane. Buffon even calculates the deviation from a uniform plane as no more than 7½ degrees. He agrees with Newton that it is highly unlikely that chance alone could result in such uniform motion, and even calculates the odds as 24 to the 5th power, "or 7962624 to 1, that this effect could not be produced by accident."[22]

To Newton, this uniformity was divine design; to Buffon it is evidence that "all the planets have probably received their centrifugal motion by one single stroke."[23] Some kind of primal celestial event must have occurred that created all the planets and set them spinning. Buffon hypothesizes that the planets were created when a comet smashed into the sun at an oblique angle, knocking out some of the sun's contents "in the form of torrents."[24] These chunks of spinning molten matter then cooled and condensed into solid orbiting globes. This explains why the earth is an oblate spheroid: That is the shape it took as centrifugal force acted on the rotating liquid sphere before the crust hardened into rigidity.

In speculating how the earth could be formed from a comet striking the sun, Buffon is engaging in *cosmogony*, a word that encompasses ideas about the origins of the entire cosmos as well as the earth itself. Buffon's speculation of the earth's formation was the first significant new cosmogony since the late 17th century. That was the period when theologians Thomas Burnet in *Theory of the Earth* and William Whiston in *New Theory of the Earth* attempted to reconcile scripture with natural law by describing how the world's progress from Creation to Deluge through the final Conflagration could occur through the actions of familiar astronomical phenomena. In *An Essay toward a Natural History of the Earth*, naturalist John Woodward focused on the Deluge, and described how the geological strata of the earth's surface — including the mysterious phenomena of seashells found on mountaintops high above the sea — were the result of the settling of material churned up following the great flood.

Buffon knew about these earlier theories and devotes an article each to Burnet, Whiston, and Woodward, patiently explaining their flaws and finally dismissing them as inadequate. He rejects Woodward's attribution of geological strata to the Deluge, and instead proposes that the "strata must have been gradually formed, and that they are not the effect of any sudden revolution." These "strata must necessarily be the operation of a uniform and constant cause," and that "the dry and habitable part of the earth has for a long tine remained under the waters of the sea, and must have undergone the same

---

[21] Buffon, *Histoire Naturelle, Générale et Particuliére, Tome Premier* (Paris: De L'imprimerie Royale, 1749), https://books.google.com/books?id=RCWs-biJZF4C.
[22] Buffon, *Natural History, General and Particular*, Volume I, trans. William Smellie (Edinburgh: William Creech, 1780), pp. 65–66. The pagination is the same in the Second Edition (London: W. Strahan and T. Cadell, 1785), https://books.google.com/books?id=LDed3YMcCPcC. The English translation does not include the Preliminary Discourse.
[23] Ibid, p. 66.
[24] Ibid, p. 70.

changes which are at present going on at the bottom of the ocean." He contends that "such a revolution would not be suddenly accomplished, but that it would require a very long period." Buffon speaks of earthquakes, volcanos, erosion from "rains, rivers, and torrents from the mountains"[25] and concludes that

> the flux and reflux of the ocean have produced all the mountains, valleys, and other inequalities of the surface of the earth; that currents of the sea have scooped out the valleys, elevated the hills, and bestowed on them their corresponding directions; that the same waters of the ocean, by transporting and depositing earth, &c. have given rise to the parallel strata…."[26]

Buffon did not attempt to make his theories fit either the book of Genesis or Christian eschatology. Consequently, his naturalistic explanation of earth's creation and history did not sit well with the Faculty of Theology in Paris, known as the Sorbonne. These were the men responsible for policing heretical publications in pre-Revolution France. They found fourteen "reprehensible statements" in Buffon's book, including his theory of planetary formation, as well as his descriptions of long-term cyclical processes of erosion and accumulation that could be interpreted as implying an eternal earth.

Buffon pleaded that he was not contradicting Scripture. He believed "very firmly all that is told about Creation, both as to the order of time and the circumstances of the facts." He presented his theory "only as a pure philosophical supposition."

Or, as he noted privately some years later, "Il vaut mieux être plat que pendu" — "It is better to be humble than hung."[27]

In ascribing the creation of the earth's strata to "a very long period," Buffon was implicitly contradicting a tradition that assumed a relatively brief age of the earth. When Rosalind says that "the poore world is almost six thousand yeeres old"[28] in Shakespeare's *As You Like It* (1599), she is merely repeating conventional knowledge. Six thousand years is the approximate length of earth's history derived from the ages and progeny of Biblical figures following the act of Creation recorded in the book of Genesis. The first five books of the Hebrew Bible and the Christian Old Testament (called the Pentateuch) were traditionally attributed to the authorship of Moses under divine influence, and were therefore considered to be a valuable source of information about the early history of the universe and mankind.

The Jewish calendar tabulates dates as *Anno Mundi*, meaning "in the year of the world," which implies that Creation took place 3,761 years before the beginning of the Christian era. Christians divide time into years designated as *Anno Domini* ("in the year of the lord") beginning with the birth of Jesus, and Before Christ (BC) for the years preceding

---

[25] Buffon, *Natural History,* Volume I, pp. 16, 17, 32, 51.
[26] Ibid, pp. 57–8.
[27] Jacques Roger, *Buffon: A Life in Natural History*, trans. Sarah Lucille Bonnefoi (Ithaca: Cornell University Press, 1997), p. 188
[28] Act IV, Scene 1.

the birth. Roman Catholics traditionally used a Latin translation of the Bible known as the Vulgate, from which a date for Creation of 5199 BC had been derived

The Protestant Reformation reinvigorated attempts to date Creation. The Protestant doctrine of *sola scriptura* ("by Scripture alone") encouraged the use of the Bible as the primary source of divine guidance rather than a reliance on papal or scholastic authority. Anyone with sufficient time and motivation could determine their own chronology by coordinating the ages and genealogy of persons in the Old Testament with people and events that could be independently dated in Egyptian, Babylonian, Greek, and Roman histories. The author of one 18th century book on sacred history collected over 200 different estimates of the date of Creation ranging from 3483 BC to 6984 BC.[29] Martin Luther himself came up with a date of 3960 BC, and even Isaac Newton indulged, although his results weren't published until after his death and he never committed to a precise date of the Creation.[30]

The most popular date of Creation became 4004 BC. This was determined in the 1650s by Irish Archbishop James Ussher, who rather suspiciously set the date exactly four millennia before the 4 BC birth of Christ.[31] Beginning in the early 1700's, Ussher's dates began being added to the margins in English-language Bibles.[32] At that time, belief in the literal truth of Genesis was nearly universal. Newton's only qualification was that Moses described the events as if they would be perceived by a naive human observer rather than as interpreted by a natural philosopher familiar with physical laws.[33] By 1800, however, the traditional chronology had been repeatedly challenged, sometimes with glee by skeptics and deists, and sometimes with anxiety by those who wished to preserve at least some of the integrity and authority of Genesis.

The demise of Mosaic chronology was part of the greatest scientific revolution since Copernicus, and one of the most significant events in the history of science. It is sometimes called a revolution in time, or a chronological revolution, or a discovery of *deep time*.[34] Just as the Copernican revolution displaced the earth from the center of the universe to reveal a space much deeper than had been previously assumed, the chronological revolution

---

[29] Alphonse Des Vignoles, *Chronologie de l'histoire sainte* [*Chronology of Sacred History*], 1738, https://books.google.com/books?id=CuVIAAAAcAAJ, Preface, pg. 3.
[30] Frank E. Manuel, *Isaac Newton, Historian* (The Belknap Press of Harvard University Press, 1963), pg. 40.
[31] Stephen Jay Gould, *Questioning the Millennium: A Rationalist's Guide to a Precisely Arbitrary Countdown* (NY: Harmony Books, 1997), pp. 89–94.
[32] See the first page of Genesis in *The Holy Bible* (Edinburgh: James Watson, 1715), https://books.google.com/books?id=-kBbAAAAQAAJ.
[33] Rob Iliffe, *Priest of Nature: The Religious Worlds of Isaac Newton* (Oxford University Press, 2017), pg. 241.
[34] The term "deep time" was popularized by John McPhee in articles about geology and geologists in *The New Yorker* and collected in the book *Basin and Range* (1981). However, the term appears prominently in J. G. Ballard's short story "The Waiting Grounds," from the June 1960 issue of *New Worlds Science Fiction* and collected in the book *The Voices of Time and Other Stories* (1962), and it is found in other writings prior to McPhee.

increased the age of the universe from thousands of years to millions and billions of years, revealing a long history of the planet and life on it.

Without this revolution in time, the Darwinian revolution would not have been possible, and together these two revolutions had profound scientific, religious, and cultural impacts. These revolutions were also the inciting incidents that influenced William Thomson's conception and construction of his tide-predicting machine.

Although astronomy played a role in this revolution in time, for the most part it was a geological revolution rather than an astronomical one. It was carried out by curious explorers who had stopped looking up at the heavens for answers to their perennial questions, and had begun looking under their feet. What they found there revealed an earth much older than Rosalind's "six thousand yeeres."

Although not much of a geologist, the Comte de Buffon was one of the first to propose that the formation of geological strata requires long periods of time. After his 1749 history and theory of the earth, Buffon turned to much less controversial researches, but his interest in planetary formation was revived in 1765 when an 86-year-old savant named Jean-Jacques d'Ortous de Mairan wrapped up some work he had been doing since 1719 regarding how the sun contributes to the warmth of the earth. The sun obviously governs the temperature difference between day and night, and between summer and winter, and in different climates around the world. But de Mairan's calculations showed that the sun does not account for the entire temperature differential. Something else is heating the earth. He knew that temperatures within the earth increase as one digs deeper, and that the sun was incapable of penetrating to the depths of the ocean. If the sun were the sole source of the earth's heat, ice would form at the bottom of the oceans and then rise to the top. All this evidence persuaded de Mairan that a source of heat must exist internal to the earth itself.

To Buffon, this was a confirmation of his earlier theory: As a recent biographer of Buffon writes: "The idea must have immediately come to him that this heat was what remained of the earth's heat at the moment that it had been torn from the sun. Since that event, the earth had cooled."[35] Determining the extent of that cooling might reveal the age of the earth. Beginning in 1767 and continuing for six years, Buffon experimented with heating balls of iron and other materials, and then measuring the time required for them to become cool. From these various cooling spheres, he extrapolated how long it would take for a molten earth to become fit for habitation.[36]

Buffon struggled with the calculations. "He tried various hypotheses that gave him higher and higher results" and then concluded that "it was probably necessary to assign the earth a probable age of at least ten million years."[37]

Ten million years! Dare he publish that result?

---

[35] Roger, *Buffon*, p. 388.
[36] Roger, *Buffon*, pp. 393 – 396.
[37] Roger, *Buffon*, p. 411.

We know now that Buffon didn't have adequate mathematical tools to solve the complex problem of a large cooling sphere. Partial differential equations are required. The man who would develop those tools was another Frenchman, born in Auxerre less than 50 miles from Buffon's birthplace of Montbard, but Joseph Fourier was still a child when Buffon was working out these calculations. Several decades later, in 1820, Fourier himself undertook the problem of a cooling earth.[38] He stopped short of calculating a value but provided a formula that with some reasonable assumptions also results in an age of about ten million years.[39] Another several decades later (as you'll see later in this book) William Thomson also tackled this problem, leading to one of the major scientific controversies of the era.

Buffon decided not to publish that estimate of ten million years. In a supplement to *Histoire Naturelle* that chronicled his experiments, Buffon retreated to some earlier calculations and concluded that the present-day earth was blasted from the sun about 75,000 years ago and has been cooling ever since. Another supplement to *Histoire Naturelle* published in 1778 called *Les Époques de la Nature*[40] expanded on the theory he first presented in 1749, but then tracked the history of the earth through seven epochs. The timeframes for these epochs were derived from the work he published earlier based on temperatures of cooling spheres.

In constructing an alternative narrative of the earth's early history, Buffon knew that he was treading into dangerous waters. He begins *The Epochs of Nature* with a preliminary discourse that attempts to reconcile the long timeframes he had found with "the sacred traditions, which provide for the world only some six or eight thousand years." Buffon quotes from Genesis but distinguishes between the creation of the matter that makes up the heavens and the earth, and how the earth eventually developed. The "beginning" that appears in the first verse of Genesis, "*this beginning*, the first time, the most ancient of all, during which the matter of the heavens and the earth existed without a determinate form, seems to have had a long duration."[41] The six days of Creation were also long periods of time:

> What can we understand by the six days that the sacred Writer shows us so precisely in counting them one after the other, if not six spans of time, six intervals of duration? And these spans of time indicated by the name of *days*, for lack of other expressions, cannot have any correspondence with our current days,

---

[38] "Refroidissement séculaire du globe terrestre," *Œvres De Fourier*, Tome Second, Paris: Gauthier-Villars et Fils, 1890, https://books.google.com/books?id=tBfQAAAAMAAJ, pp. 271–288.
[39] Ibid, p. 284, with *b*, the initial temperature, set to the melting point of iron (1538° C), Δ set to 1/30, and the CD/K ratio set to 8 times 1033 as suggested in the text. See also Joseph Boussinesq, *Théorie analytique de la chaleur*, Paris: Gauthier-Villars, 1903, pp. 22–24, where an initial temperature of 1000° C results in a duration of five million years.
[40] Recently available in an English translation: Georges-Louis Leclerc, le comte de Buffon, *The Epochs of Nature*, trans. Jan Zalasiewicz, Anne-Sophie Milon, and Mateusz Zalasiewicz (University of Chicago Press, 2018).
[41] Ibid, pp. 15, 16.

> because three of these passed before the Sun had been placed in the sky. It is thus not possible that these days were like ours…[42]

Even when it comes to dating the advent of the human race to just several thousand years ago, Buffon equivocates. He is willing to allow that timeframe, but not if it contradicts the evidence of nature.

> It is fine that one can say, that one can uphold, even rigorously, that since the latest phase, since the end of the works of God, that is to say since the creation of man, there has been no more than six or eight thousand years, because the different genealogies of the human kind since Adam do not indicate more. We owe this belief, this mark of submission and respect to the most ancient, the most sacred of traditions; we owe it yet more, that it can never allow us to deviate from the letter of the sacred tradition except when *the letter kills*, that is to say, when it is directly opposed to healthy reason and to the truth of the facts of Nature. Because all reason, all truth, comes equally from God, there is no difference between the truth that He has revealed and the truth that we are allowed to discover by our observations and our researches.[43]

If conflicts exist between God's words and God's works, Buffon clearly favors the latter.

Following this preliminary discourse, *The Epochs of Nature* constructs a grand narrative that divides the history of the earth into seven epochs following its expulsion from the sun. In the third epoch, water still covers the earth, but there is life in the warm seas that has left its remnants in fossils. By the fifth epoch, the northern part of Europe and North America has cooled to the point where elephants and other large mammals are able to survive. They have left their fossils in the northern climes, but as the earth continues to warm, these large mammals migrate south, and that's why today we only find living elephants in Asia and Africa. The continents separate in the sixth epoch, and in the seventh, humans appear and civilization follows.

Buffon's earlier theory of the earth suggested a long history of cyclical geological processes. But a progressively cooling earth is no longer cyclical. It has an overall directional process from hot to cold. As the earth continues to cool in the future, it will again become uninhabitable. This frosty end to the earth is quite different from the fiery conflagrations of the theories of Burnet and Whiston, based as they were on the Book of Revelation. "Some say the world will end in fire, / Some say in ice," Robert Frost wrote in 1920. Buffon said ice.

Despite Buffon's willingness to reconcile his narrative with scripture, the theologians of the Sorbonne were not impressed. But this time they were hesitant to act. It was almost three decades since the first volume of *Histoire Naturelle* and Buffon was much

[42] Ibid, p. 18.
[43] Ibid, p. 19.

more famous. The Sorbonne did get a retraction from him, and they published it, but nobody cared much anymore.[44]

Around the same time as Buffon's *Epochs of Nature*, several other books were published in Britain representing a variety of approaches to interpreting earth's history.

In 1778, the same year as Buffon's *Epochs*, appeared *An Inquiry into the Original State and Formation of the Earth*. It's author, John Whitehurst, was primary a maker of clocks and other instruments, such as sundials and barometers, but he devised more extensive mechanisms for plumbing and heating homes, and he contributed significantly to the development of the steam engine.[45] He was the oldest of the dozen or so polymaths and freethinkers known as the Lunar Society of Birmingham (and chronicled by historian Jenny Uglow[46]), so called because they regularly met during the full moon for safer travel at night. Their numbers included Joseph Priestly, James Watt, Erasmus Darwin (Charles's grandfather), and the pottery entrepreneur Josiah Wedgwood (also Charles Darwin's grandfather).

Whitehurst's interest in the geology of Derby was "in part to obtain such a competent knowledge of subterraneous geography, as might become subservient to the purposes of human life, by leading mankind to the discovery of many valuable substances which lie concealed in the lower regions of the earth."[47] These substances included coal, iron ore, marble, and gypsum.

The *Inquiry into the Original and Formation of the Earth* does just that — particularly in the Appendix that describes the geology of Derbyshire in more detail — but it also uses the geological strata to construct a history of the earth. Early on, John Whitehurst asserts that "the earth had a beginning, and cannot have existed from eternity, as some persons have imagined."[48] The idea of an eternal earth was considered very atheistical for it left no opportunity for God to create it.

In the very first page of the preface, Whitehurst draws a connection between the order of the strata and what is found within them:

> It may appear wonderful, that amidst all the confusion of the strata, there is nevertheless one constant invariable order in the arrangement of them, and their

---

[44] Roger, Buffon, pp. 422–423.
[45] For biographical information, see Maxwell Craven, *John Whitehurst: Innovator, Scientist, Geologist, and Clockmaker*, Fonthill, 2015.
[46] Jenny Uglow, *The Lunar Men: Five Friends Whose Curiosity Changed the World*, NY: Farrar, Straus and Giroux, 2002.
[47] Quoted in Craven, *John Whitehurst*, p. 94.
[48] John Whitehurst, *An Inquiry into the original State and Formation of the Earth; deduced from Facts and the Laws of Nature, to which is added an Appendix, Containing some General Observations on the Strata in Derbyshire*, London: J. Cooper, 1778, https://books.google.com/books?id=bSeuv-zAOnMC, p. 9.

> various productions of animal, vegetable, and mineral substances, or rather the figures or impressions of the two former.[49]

That various levels of strata might be identified by their imbedded fossils was to become an extremely important analytical tool in tracing the strata's history.

Throughout his book, Whitehurst draws parallels between his natural history and Genesis. Based on his explorations of the strata of Derbyshire, Whitehurst notes that the deepest levels of strata contain marine animals. These, he says, date from when the earth was covered with water before primitive islands were "raised, by the flux and reflux of the tides, as sand-banks are formed in the sea."[50] Strata corresponding to this later era contain fossil remnants of plants, while more recent strata contain animal fossils. The successive ages revealed in the layers of strata correspond to the order of Creation in scripture.

Whitehurst sees evidence in the strata "that subterraneous convulsions were much more violent in the early ages of the world, than they have been since the commencement of history" but attributes this to natural processes and ancient volcanos, and just "one universal deluge."[51] This flood changed not only the landscape of the world but its climate: In antediluvian days, the world was a lot flatter, leading to more temperate climates around the world. Whitehurst cites a census during the reign of Vespasian in the year 76 AD that recorded a number of citizens of Italy above the age of 100 and one as old as 150. He concludes that warmer climates promote greater longevity. This accounts for the long lifespans of people before the flood (including Adam's 930 years and Methuselah's 969 years), contrasted with the drastic drop in lifespans in the postdiluvian world, down to a mere 175 for Abraham, 147 for Jacob, and 110 for Joseph. These observations contribute to "the great analogy between revelation and reason [which] may be considered as corroborating the truth of each."[52]

Despite the parallels he draws between earth history and Genesis, Whitehurst avoids attributing anything to miracles. The changes in the earth occur solely as a result of natural processes. These processes are understood to be long, slow, and progressive, but Whitehurst sidesteps any talk of timescales. He has implicitly incorporated a more metaphorical understanding of the days of Creation.

Early drafts of Whitehurst's book were apparently less laden with Genesis than the published version. Whitehurst's more free-thinking friends in the Lunar Society were disappointed with the quantity of Genesis in the book. Josiah Wedgwood wrote that he was

> fully perswaded his manuscript has undergone as many alterations since its first formation by the *fine philosopher* of Derby as his world has suffer'd by earthquakes, & inundations … I own myself astonish'd beyond measure at the

[49] Ibid, p. i.
[50] Ibid, p. 28.
[51] Ibid, pp. 73, 101.
[52] Ibid, p. 135.

> labour'd & repeated efforts to bring in & justify the mosaic account beyond all rhime or reason.[53]

A much more materialist and non-religious vision of the earth was offered by George Hoggard Toulmin. His 1780 book *The Antiquity and Duration of the World* proposes that the earth and everything that lives on it has existed forever without the benefit of any type of miraculous creation. Historian Roy Porter calls Toulmin's book "an overt gesture of political radicalism" that was "meant to provoke … Christian anger."[54]

Toulmin attended Edinburgh University in the 1770's when it was a hub of the Scottish Enlightenment. His time there would have exposed Toulmin to "the more speculative naturalistic philosophers of the French Enlightenment."[55] The timing is also right for Toulmin to have encountered David Hume's posthumously published devastating takedown of natural theology, *Dialogues Concerning Natural Religion*, which appeared in 1779, the same year that Toulmin graduated as a medical doctor.

In *The Antiquity and Duration of the World*, Toulmin comes charging like a one-man cavalry of the Enlightenment. He has little patience with "the baneful and gloomy influence of Gothic barbarism and superstition" and those who would "trace their own lineal descent from their first imaginary parents" and "persuade us, that Nature is but of some thousand years duration." Toulmin refuses even to pay lip service to the conventions of natural theology — establishing himself as more atheist than deist — and seems to suggest that even challenging religious assumptions is beneath him. In its place are nature's "laws fixed and immutable." [56]

Quoting Buffon, Whitehurst, and others, Toulmin attributes all the features of the earth to "the effect of uniform operations, — the gradual product of time and of natural causes."[57]

> No longer are we to regard the loftiest mountains, as of original and permanent existence. Formed, as well as ourselves, by gradual processes, they are subject to the most regular changes. At one period they rear their lofty summits to the skies; at another, no longer exist. Thus is every production of nature unstable and subject to perpetual variations.…
>
> These immutable truths should never be forgot: That animals and vegetables flourish and decay; that earths are formed by slow degrees; that they too change

---

[53] Quoted in Uglow, *The Lunar Men*, pp. 300–301.
[54] Roy Porter, "Philosophy and Politics of a Geologist: G. H. Toulmin (1754–1817), *Journal of the History of Ideas*, Vol. 39, No. 3 (Jul. – Sep., 1978), 435 – 450, pp. 436, 440
[55] Roy Porter, "George Hoggart Toulmin's Theory of Man and the Earth in the Light of the Development of British Geology," *Annals of Science*, Vol. 35, No. 4 (July 1978), 339–352, p. 341.
[56] George Hoggart Toulmin, *The Antiquity and Duration of the World* (London: T. Cadell, 1780), https://books.google.com/books?id=RNgPAAAAQAAJ, pp. vii, 3, 33, 186.
[57] Ibid, p. 51.

> by time; that stone is formed, is decomposed or altered in its composition; that mountains now are elevated, now depressed; — that nature lives in motion.[58]

Toulmin also believed that the human race has existed forever: "Though men are seen to die, or change existence, the human species flourish in eternal being!" Another exclamation point caps his statement "That the human species have had, and will have, an uniform and infinite existence!" Because the human race is part of the earth, "an unerring uniformity is preserved throughout the whole of nature."[59]

Over the remainder of the decade, Toulmin continued to revise, expand, and retitle his book as *The Antiquity of the World* (1783), *The Eternity of the World* (1785), and *The Eternity of the Universe* (1789). Toulmin's complete rejection of religion was a rarity among the explorers of earth science in this era, but as the French Revolution progressed and the Napoleonic Wars followed, Toulmin seems to have abandoned both his atheism and his interest in antiquity of the world. He took up poetry and humanitarian concerns, such as William Wilberforce's campaign to abolish the slave trade.[60]

To those who stuck to a strictly literal interpretation of Genesis, it must have seemed that the geologists' hammers were not only shattering rock but chipping away at the very foundations of faith. The tap-tap-tap of these hammers was loud enough that even a sensitive English evangelical poet could hear them. From the depths of his 1785 blank-verse epic *The Task*, William Cowper sounded an alarm of prescient panic couched in coy irony:

> Some drill and bore
> The solid earth, and from the strata there
> Extract a register, by which we learn
> That he who made it and reveal'd its date
> To Moses, was mistaken in its age.[61]

Sometimes when this passage is quoted, the "he" is capitalized but it's not in the first edition, and yet there's no mistaking that the pronoun refers to God, who obviously (in Cowper's view) could not have been mistaken in conveying the earth's history and implied age to Moses.

William Cowper didn't personally know any of these people who were drilling into geological strata and concluding that the earth was older that six millennia. He got his information by reading popular periodicals such as *The Monthly Review*, whose writers wouldn't hesitate to alert their readers to dangerous or heretical ideas lurking between the covers of the books they reviewed.[62] Anybody reading these same periodicals could have

---

[58] Ibid, pp. 95–6, 172.
[59] Ibid, pp. 120, 187, 194.
[60] Porter, "Philosophy and Politics of a Geologist," pp. 446–450.
[61] William Cowper, *The Task, a Poem, in Six Books* (London: J. Johnson, 1785), Book III, Lines 150–4, p. 99.
[62] Charles Petzold, "William Cowper and the Age of the Earth" (June 2019), http://www.charlespetzold.com/essays/WilliamCowperAndTheAgeOfTheEarth.pdf.

drawn the same conclusion that Cowper did: that some kind of intellectual upheaval involving geology was already in progress by this time.

Following his indictment of those who drill and bore, Cowper goes on to attack the more speculative natural philosophers who dare to theorize how the stars and planets might have come to exist and take their place in the universe:

> Some more acute and more industrious still
> Contrive creation. Travel nature up
> To the sharp peak of her sublimest height,
> And tell us whence the stars. Why some are fixt,
> And planetary some. What gave them first
> Rotation, from what fountain flow'd their light.[63]

In these lines he might very well be thinking of Buffon, for his theories were mocked in Cowper's favorite periodical. But Cowper's critique then goes deeper. Philosophical skeptics like David Hume weren't the only people detecting flaws in natural theology. Evangelicals wondered if the study of the natural world truly brought people closer to God:

> Great contest follows, and much learned dust
> Involves the combatants, each claiming truth,
> And truth disclaiming both. And thus they spend
> The little wick of life's poor shallow lamp,
> In playing tricks with nature, giving laws
> To distant worlds and trifling in their own.[64]

To evangelicals, the empiricism of natural theology was a poor substitute for faith, particularly when wayward studies of the natural world contradicted the truth of revelation.

Even in that year of 1785 when *The Task* was published, English clergymen were themselves acknowledging that the earth might be older than Genesis suggested. Moses was perhaps not "mistaken in its age" but maybe stretching the truth a bit.

One such cleric was the Reverend James Douglas, whose experience with antiquarian studies allowed him to use that same skill set to analyze fossils. In 1785, Rev. Douglas read a paper to the Royal Society later published as *A Dissertation on the Antiquity of the Earth*. Douglas examines several fossils whose degree of petrification seemed to him to predate the Deluge, and was instead the result of some earlier event. He emphasizes with italics that "*by the undoubted testimony of these petrified animal bones, they must have been interred much anterior to any written record, from some extraordinary convulsion of the globe.*"[65] The "written record" he refers to includes the Bible, so the fossils predate those chronicles.

---

[63] William Cowper, *The Task,* lines 155–160.
[64] Ibid, lines 161–166.
[65] James Douglas, *A Dissertation on the Antiquity of the Earth*, (London: Logographic Press, 1785), https://books.google.com/books?id=vaAAAAAAMAAJ, p. 12.

In an Appendix, Douglas describes the remains of a "Fossil Quadruped incognitum."[66] This is a jaw that constitutes "the remains of an animal no longer known. The species seems to have been extinct; the cause apparently derived from that revolution of the earth, which universally prevailed at the remote period of time, which I have more fully enlarged upon in the preceding discourse."[67] The implications of extinction will become more apparent in the years to come.

Douglas reconciled an apparent vast age of the earth with Genesis by noting the difficulty in counting days prior to the creation of the sun. Consequently,

> many well-informed persons have therefore been inclined to suppose that the earth was created in six expanses of time, instead of six days; and with these sentiments they have not been at a loss to account for all our natural phænomena: these arguments have been likewise stated to prove, that Moses, when he addressed himself to the children of Israel to satisfy the vulgar mind on the nature of the creation, framed his discourse in figures and terms best adapted to their simple and untutored state; and then admitting familiar incident to physical disquisition, he adopted the solar day instead of explaining a complicated system of physical argument to an unlettered multitude, into whom this great inspired lawgiver was desirous of instilling an awful respect for creation, and above all, religious sentiments for the great obligations due to a supreme invisible power; he was therefore instructed by the Almighty to make use of a familiar vehicle for the purpose; a system of nature, which all minds could conceive, and which was equally just with the more profound, though exemplary science.

This assumption of metaphorical days is familiar from Buffon. The idea that Moses was addressing himself to the "vulgar mind" of the common people was also Newton's opinion, although Newton never claimed that the "days" of Genesis were long eras, except possibly those preceding the creation of the sun.

English clergymen like Douglas realized that the most important goal was to preserve the overall integrity of the Bible. If they needed to make concessions regarding the literal reading of Genesis, that was a small price to pay. In Douglas's view, it doesn't matter whether one believes that the Creation occurred in literal days or more figurative days if the spiritual message remains intact:

> If we therefore respect the history of the world, according to the Mosaical doctrine in its ordinary significance, or by its more complicated import, the religious and well-regulated mind, will have the same cause for venerating the great plastic hand of the deity, to whom the creation of matter was in every sense equally efficacious, and to whom time, whether minute, day, or æra, was of no

[66] Ibid, p. iii. (The phrase only appears in the table of contents)
[67] Ibid, p. 44.

> account; the power of the Almighty would be still manifest, and fully as important, as we find it to be recorded in the first book of Genesis.[68]

The year 1785 also marked the public debut of James Hutton's theory of the earth, which was to provoke great opposition but also become extremely influential.

Hutton was born in Edinburgh in 1726, ten months before the death of Isaac Newton. His higher education began at the University of Edinburgh, where he was introduced to Newtonian concepts and analysis by Newton's protégé and popularizer, Colin Maclaurin, who might also have planted the seeds of Hutton's deism. Hutton's initial interests gravitated more towards chemistry and medicine. He went on to the University of Paris and then graduated with a Doctor of Medicine degree from Leiden University in the Netherlands.[69] He wrote his dissertation on the circulation of blood, which he analyzed as a cyclical process of depletion and replenishment.[70] Cyclical processes would come to characterize Hutton's interpretations of nature.

When Hutton returned to Scotland, he took over his family estate and became a gentlemen farmer with advanced ideas on how to improve his crops. He experimented with agricultural innovations and explored meteorology, particularly how water evaporating from the earth forms into clouds, which then become sufficiently saturated to precipitate into rain.[71] Another cyclical process.

During this time, Hutton hovered on the fringes of the Scottish Enlightenment. He knew David Hume (although it's not quite certain they ever met) and he was friends with Adam Smith. Even some of the economic transactions described in Smith's famous book *The Wealth of Nations* (published in 1776) could also be interpreted as cyclical processes. Hutton was introduced to James Watt, who had made improvements to the Newcomen steam engine, a machine that used heat to control the expansion and condensation of steam in yet another cyclical process.[72]

To Hutton, it would make no sense for God to create a world in which soil was washed into the sea through erosion. The earth would need a complementary mechanism to replenish the land. As the historian Martin Rudwick observes: "Natural theology had long emphasized the significance of systems that maintained themselves in dynamic

---

[68] Ibid, pp. 40-42.

[69] Biographical information is available in two fairly recent books: Stephen Baxter, *Ages in Chaos: James Hutton and the Discovery of Deep Time* (NY: Forge, 2003), originally published in Great Britain under the title *Revolutions of the Earth*; and Jack Repcheck, *The Man Who Found Time: James Hutton and the Discovery of the Earth's Antiquity* (Cambridge, MA: Perseus Books, 2003). A less biographical but more long-term historical treatment is Dennis R. Dean, *James Hutton and the History of Geology* (Cornell University Press, 1992).

[70] Dean, *James Hutton*, p. 2.

[71] Martin J. S. Rudwick, *Earth's Deep History: How It Was Discovered and Why It Matters* (University of Chicago Press, 2014), page 69.

[72] Martin J. S. Rudwick, *Bursting the Limits of Time: The Reconstruction of Geohistory in the Age of Revolution*, University of Chicago Press, 2005, page 162.

equilibrium; Hutton was simply extending that kind of argument from the organic world to the inorganic."[73]

Hutton had been contemplating this theory for 20 years prior to his paper presented to the recently founded Royal Society of Edinburgh on March 7 and April 4, 1785. It's possible that the title at that time mentioned something about "the System of the Earth, It's Duration, and Stability." Those are the words used in an Abstract published later that year.[74] But the society was so new that the paper's full publication had to wait until 1788, when the first *Transactions of the Royal Society of Edinburgh* appeared. The title of the 96-page paper then became "Theory of the Earth; or an Investigation of the Laws observable in the Composition, Dissolution, and Restoration of Land upon the Globe."[75]

Hutton describes the earth as a "machine," but the word is neither metaphor nor simile. The paper beings:

> When we trace the parts of which this terrestrial system is composed, and when we view the general connection of those several parts, the whole presents a machine of a peculiar construction by which it is adapted to a certain end. We perceive a fabric, erected in wisdom, to obtain a purpose worthy of the power that is apparent in the production of it.[76]

In those two sentences, Hutton places his theory solidly within the tradition of natural theology. The earth has been designed for a purpose, which is revealed a few pages later:

> The globe of this earth is evidently made for man. He alone, of all the beings which have life upon this body, enjoys the whole and every part; he alone is capable of knowing the nature of this world, which he thus possesses in virtue of his proper right; and he alone can make the knowledge of this system a source of pleasure and the means of happiness.[77]

Throughout the paper, Hutton will go no further in describing a role for God other than the creation of this "beautiful machine."[78] At one point he had written a preface[79] that defends his theory from any "Suspicion of Impiety," but he suppressed it. In the published version of the paper, no attempt is made to reconcile his system with the Genesis narrative, and there is no mention of a universal flood.

---

[73] Rudwick, *Bursting the Limits of Time*, page 163.
[74] *The 1785 Abstract of James Hutton's Theory of the Earth* (Edinburgh: Scottish Academic Press, 1987).
[75] James Hutton, "Theory of the Earth," *Transactions of the Royal Society of Edinburgh*, Vol. I, Edinburgh: J. Dickson, 1788, https://books.google.com/books?id=taNbAAAAcAAJ, pages 209 – 304. An offprint was also published that Hutton distributed, https://books.google.com/books?id=4rwB5Fam1RQC. Page numbers in footnotes refer to the *Transactions*; subtract 208 for the page number in the offprint.
[76] Ibid, p. 209.
[77] Ibid, pp. 216–7.
[78] Ibid, p. 215.
[79] Available in Dean, *James Hutton*, pp. 19–21.

Hutton knows that the earth is much older than "the Mosaic history" or "any document by which a high antiquity might be attributed to the human race," for we find that "the inferior species of animals … had long existed."[80] At the time of Hutton's paper, most of the evidence for a long existence of animals was confined to fossilized creatures of the sea rather than those of the land. It is not clear from the essay if Hutton believes that the existence of the human race is recent or extends far into the past, but his teleological view of the earth's purpose seems to imply that humans have existed as long as the earth has.

Hutton major revolutionary assumption is that the earth of the past was much like the earth of the present, which will be much like the earth of the future:

> In what follows, therefore, we are to examine the construction of the present earth, in order to understand the natural operations of time past; to acquire principles, by which we may conclude with regard to the future course of things, or judge of those operations, by what a world, so wisely ordered, goes into decay; and to learn, by what means such a decayed world may be renovated, or the waste of habitable land upon the globe repaired.[81]

This concept was to have a profound influence in geological thinking.

A world inhabited by humans must have both land and water, and it is through the interaction between the land and water that Hutton's machine operates. Over the course of time, erosion from wind and rain causes the land to go into the sea, where strata are formed "by means of heat and fusion."[82] A constant source of heat internal to the earth is crucial to Hutton's theory.

To Hutton, seashells on the mountaintops are not the result of a universal flood, but by land and sea swapping places:

> It is a truth unquestionable, that what had been originally at the bottom of the sea, is at present the highest of our land. In explaining this appearance, therefore, no other alternative is left, but either to suppose strata elevated by the power of heat above the level of the present sea, or the surface of the ocean reduced many miles below the height at which it had subsisted during the collection and induration of the land which we inhabit.[83]

Hutton reasons that the latter operation is unlikely. Instead, the subterraneous heat triggers volcanos whose sole purpose is to lift the seabed above the waters:

> Volcanos are natural to the globe, as general operations; but we are not to consider nature as having a burning mountain for an end in her intentions, or as a principle purpose in the general system in the world. The end of nature in placing an internal fire or power of heat, and a force of irresistible expansion, in

---

[80] Hutton, "Theory of the Earth," p. 217.
[81] Ibid, p. 218.
[82] Ibid, p. 254.
[83] Ibid, p. 263–4.

> the body of this earth, is to consolidate the sediment collected at the bottom of the sea, and to form thereof a mass of permanent land above the level of the ocean, for the purpose of maintaining plants and animals.[84]

The process of land being elevated out of the sea became known as "uplift."

In the last part of "Theory of the Earth," Hutton alludes to the ideas of Thomas Burnet that the present earth represents a decayed form of a formerly perfect pristine globe ravaged from the effects of the Deluge:

> Philosophers observing an apparent disorder and confusion in the solid parts of the globe, have been led to conclude that there formerly existed a more regular and uniform state, in the constitution of the earth; that there had happened some destructive change; and that the original structure of the earth had been broken and disturbed by some violent operation, whether natural, or from a supernatural cause.[85]

To Hutton, however, the apparent decay and renovation of the earth is an ongoing natural process as perpetual as the planets spinning around the sun:

> a world conceived in consummate wisdom for the growth and habitation of a great diversity of plants and animals; and a world peculiarly adapted to the purposes of man, who inhabits all its climates, who measures its extent, and determines its productions at his pleasure.[86]

How old is the earth? Hutton does not know, for "we might just as well measure the distance to the stars without a parallax."[87] (This was before William Herschel attempted to do precisely that.) Hutton then concludes his paper with the most famous sentence in the history of British geology:

> The result, therefore, of our present enquiry is, that we find no vestige of a beginning, — no prospect of an end.[88]

What did Hutton mean by this? Did he mean that the earth existed forever?

Probably not. It is more likely that Hutton intended this statement to refer only to the limits of human knowledge. Because the earth reveals only the long-term effects of familiar cyclical processes, we can't detect when it was created or when it will end. But the ambiguity of Hutton's final statement invited attacks. One of the first was a 1789 book by a mineral surveyor named John Williams entitled *The Natural History of the Mineral Kingdom*. In the Preface, Williams says that he has just "perused a New Theory of the Earth, by James Hutton" and wants "beg leave to make a few remarks,"[89] which then go on

---

[84] Ibid, p. 275.
[85] Ibid, p. 285.
[86] Ibid, p. 294–5.
[87] Ibid, p. 298–9.
[88] Ibid, p. 304.
[89] John Williams, *The Natural History of the Mineral Kingdom*, Vol. I (Edinburgh: Ruddiman, 1789), https://books.google.com/books?id=T29bAAAAQAAJ, p. xxiii.

for nearly 40 pages. Williams takes particular issue with the idea that the world has existed forever:

> The wild and unnatural notion of the eternity of the world leads first to scepticism, and at last to downright infidelity and atheism. If once we entertain a firm persuasion that the world is eternal, and can go on by itself in the reproduction and progressive vicissitude of things, we may then suppose that there is no use for the interposition of a governing power; and because we do not see the Supreme Being with our bodily eyes, we depose the almighty Creator and Governor of the universe from his office, and instead of divine providence, we commit the care of all things to blind chance…. Let us turn our eyes from the horrid abyss, and stretch out our hands, and cry, Save, Lord, or we perish![90]

The year 1789 was also the beginning of the French Revolution, whose paradoxes famously recorded by Charles Dickens include "it was the epoch of belief, it was the epoch of incredulity." The enthusiasm of some English men and women for the Revolution manifested itself in philosophical attacks on the Bible, and the Creation story was an easy target. In *A Vindication of the Rights of Woman* (1792), philosopher and feminist Mary Wollstonecraft observes how "Moses's poetical story" about Eve being made from one of Adam's ribs is used to support male domination of women,

> as it proves that man, from the remotest antiquity, found it convenient to exert his strength to subjugate his companion, and his invention to show that she ought to have her neck bent under the yoke; because she as well as the brute creation, was created to do his pleasure.[91]

Two years later, in her *View of the French Revolution*, Wollstonecraft writes how the concept of original sin has prevented people from achieving true happiness. She lumps "the eating of the apple" with "the theft of Prometheus, the opening of Pandora's box, and the other fables, too tedious to enumerate, on which priests have erected their tremendous structures of imposition, to persuade us, that we are naturally inclined to evil."[92]

Even more direct was the outspoken English-born American patriot Thomas Paine, whose follow-up to his 1791 *The Rights of Man* was the 1795 deist polemic *The Age of Reason*, in which he took direct aim at the Biblical stories that had nurtured countless generations of English children:

> Take away from Genesis the belief that Moses was the author, on which only the strange belief that it is the word of God has stood, and there remains nothing of Genesis, but an anonymous book of stories, fables, and traditionary or invented

---

[90] Ibid, pp. lix, lxii.

[91] Mary Wollstonecraft, *A Vindication of the Rights of Woman: with Strictures on Political and Moral Subjects* (1792), Chapter II (https://books.google.com/books?id=mQpgAAAAcAAJ, pg. 26). In the 2nd edition, the end of the paragraph was changed to "… because, the whole creation was only created for his convenience or pleasure.")

[92] Mary Wollstonecraft, *An Historical and Moral View of the Origin and Progress of the French Revolution; and the Effect it has Produced In Europe* (1794), Book I, Chapter I (https://books.google.com/books?id=y7dCAQAAMAAJ, pg. 17)

> absurdities, or of downright lies. The story of Eve and the serpent, and of Noah and his ark, drops to a level with the Arabian Tales, without the merit of being entertaining, and the account of men living to eight and nine hundred years, becomes as fabulous as the immortality of the giants of the Mythology.[93]

As the French Revolution revealed its horrific side, and as France warred against England, the English became more religiously conservative. If severed heads were the result of religious doubt, the English were having none of it. This was the era of the tracts of Hannah More and of William Wilberforce's scathing 1797 critique of English religious laxity, *A Practical View of the Prevailing Religious System of Professed Christians, in the Higher and Middle Classes of this Country, contrasted with Real Christianity*.[94]

During the 1790s, James Hutton worked on a multivolume book on his theory of the earth, but he considered it subservient to a book on epistemology, so he finished a three-volume *Investigation of the Principles of Knowledge* first, and was only able to publish two volumes of *Theory of the Earth* in 1795 before his death two years later.

Hutton's strict adherence to uniform processes influenced the way he interpreted fossils. Some geologists had begun using the words *primary* to discuss those deep rock formations without any fossils; *secondary* for those strata on top of the primary with remnants of seashells, fish, and reptiles; and *tertiary* for the uppermost strata containing birds and mammals. These terms implied a type of progression from a time prior to the existence of life, to a period with less advanced species, culminating in a time of more complex species that we know today.

This progression of living things violates Hutton's concept of uniform cyclical processes, and he uses many pages in *Theory of the Earth* to refute it, concluding "This only is certain, from what we see, that there is nothing formed in one epocha of nature, but what has been repeated in another, however dissimilar may be the operations which had intervened between those several epochs."[95]

Hutton's theories were attacked from various perspectives, including the scientific and the religious. Jean André de Luc, who served as a kind of science advisor to Queen Charlotte (wife of George III), wrote four articles in the form of open letters to Hutton that appeared in the *Monthly Review* in 1790 and 1791. Five years later, he wrote an anonymous three-part review of the two volumes of Hutton's *Theory of the Earth*, concluding by asserting that "our continents have not existed a longer time than is determined by the Mosaic chronology since the Deluge." He warns that a superficial study of geology

> would make us forget that sacred history, which, at the same time that it gives us the first true information on the origin of the universe and the history of the

---

[93] Thomas Paine, *The Age of Reason: Being an Investigation of True and Fabulous Theology*, Part II (London: H.D. Symonds, 1795), https://books.google.com/books?id=PVKLOSiUQIMC, p. 14.
[94] Jenny Uglow, *In These Times: Living in Britain through Napoleon's Wars, 1793–1815* (NY: Farrar, Straus, and Giroux, 2014), ch. 25.
[95] James Hutton, *Theory of the Earth, with Proofs and Illustrations* (Edinburgh: Cadell and Davies, 1795), p. 364.

> earth, teaches us the purpose of these Revelations from the author of nature; that of prescribing to men precise duties, and giving a certain, but conditional, foundation to their future hope.[96]

The devout Irish chemist and mineralogist Richard Kirwan asked in the pages of the *Transactions of the Royal Irish Academy* (an organization he would soon be President of),

> why should we suppose this habitable earth to arise from the ruins of another anterior to it, contrary to reason and the tenor of the mosaic history? What do we gain by that supposition? Must not the origin of that anterior world, if composed of materials similar to those of this, be equally accounted for? … must we allow that anterior solid land to have been itself also formed of the ruins of another still prior to it, and thus admit a process *in infinitum*; an abyss from which human reason recoils?[97]

Many of the opponents of Hutton were drawn to the ideas of Abraham Gottlob Werner, whose theories derived from his experience as a professor at the prestigious Freiberg Mining Academy in Saxony. While Hutton held that the earth's internal heat was responsible for forming rocks and strata, Werner believed that the pressure of water alone was sufficient. Even basalt — now known as the most common form of volcanic rock — was believed by Werner to be formed in the ocean.[98] Werner's aqueous origin of strata were more comforting to those struggling to preserve the existence of the Deluge. In truth, Werner also believed that the earth was quite old: Perhaps a million years had elapsed since the earth was covered with water.[99]

By the end of the century, the different geological camps were identified with names that suggested cults of Roman gods: Werner was the primary Neptunist, named for the god of the sea. Hutton was often classified as a Vulcanist, but strictly speaking, the Vulcanists tended to believe that volcanos were the primary mechanism behind changes in the earth. Others classified Hutton as a Plutonist, after the god of the fiery underworld.

Following Hutton's death in 1797, his friend John Playfair — at the time a professor of mathematics as the University of Edinburgh and later professor of natural philosophy — took up Hutton's cause. Playfair had gone on geological expeditions with Hutton and in 1788 they had discovered what is now called the Hutton Unconformity at Siccar Point in Scotland. One formation of parallel strata had been broken and dislodged from its initial horizontal state, and then subjected to erosion and covered with additional layers of horizontal strata, clearly revealing that these two sections had been deposited at two

---

[96] [Jean André de Luc], "Hutton's Theory of the Earth", *The British Critic* (Vol. VIII, July-Dec., 1796), https://books.google.com/books?id=onFPAQAAMAAJ, pp. 598–606. Quotation from p. 606.
[97] Richard Kirwan, "Examination of the Supposed Igneous Origin of Stony Substances," *The Transactions of the Royal Irish Academy*, Vol. V (Dublin, c. 1793), https://books.google.com/books?id=X4MFAAAAQAAJ, pp. 51–81. Quotation from pp. 63–64.
[98] Anthony Hallam, *Great Geological Controversies*, 2nd edition (Oxford University Press, 1989), p. 7.
[99] Dean, *James Hutton*, pp. 91–97.

separate remote times, not during one Deluge. "The mind seemed to grow giddy by looking so far into the abyss of time," Playfair later wrote.

In 1802 Playfair published *Illustrations of the Huttonian Theory of the Earth*[100] hoping to rescue Hutton from the curse of his graceless and verbose writing. Playfair's intent was to explain Hutton's theory "in a manner more popular and perspicuous than is done in his own writings,"[101] reducing Hutton's theory to 140 pages of crisp, clean prose (albeit supplemented with another 380 pages of Notes and Additions).

Playfair also needed to confront the critics of Hutton's theory. He realized that "the high antiquity ascribed by it to the earth, is inconsistent with that system of chronology which rests on the authority of the Sacred Writings" but asserts that the objection is only valid if this antiquity

> were also extended to the human race. That the origin of mankind does not go back beyond six or seven thousand years, is a position so involved in the narrative of the Mosaic books, that any thing inconsistent with it, would no doubt stand in opposition to the testimony of those ancient records. On this subject, however, geology is silent …[102]

Playfair compares Hutton with Copernicus, and pleads that "the Scriptures are not intended to resolve physical questions." If we rely on the Bible for all our information about the world, we would still believe "that the earth is flat; that the sun moves round the earth; and that the circumference of a circle is no more than three times its diameter."

> It is but reasonable, therefore, that we should extend to the geologist the same liberty of speculation, which the astronomer and mathematician are already in possession of; and this may be done, by supposing that the chronology of Moses relates only to the human race. This liberty is not more necessary to Dr Hutton than to other theorists. No ingenuity has been able to reconcile the natural history of the globe with the opinion of its recent origin; and accordingly the cosmologies of Kirwan and De Luc, though conceived with more mineralogical skill, are not less forced and unsatisfactory than those of Burnet and Whiston.[103]

Among those who had already concluded that the earth was much older than Moses supposed, two distinct paradigms had developed: Either the history of the earth reflected a direction from creation to an uninhabitable state, or it was forever cyclical with no vestige of a beginning or end. Stephen Jay Gould summed up these two paradigms in the title of his book *Time's Arrow, Time's Cycle*.[104]

---

[100] John Playfair, *Illustrations of the Huttonian Theory of the Earth* (Edinburgh: Cadell and Davies, 1802), http://lhldigital.lindahall.org/cdm/ref/collection/earththeory/id/51246.
[101] Ibid, p. iii.
[102] Ibid, p. 125.
[103] Ibid, pp. 126–7.
[104] Stephen Jay Gould, *Time's Arrow, Time's Cycle: Myth and Metaphor in the Discovery of Geological Time* (Harvard University Press, 1987).

In Buffon's view, the earth originated in a molten glob knocked from the sun. The earth needed to cool sufficiently to support life, but it will continue to cool and eventually get so cold that all life will be extinguished. This is a directional cosmology with a beginning and an end (at least as far as its ability to support life). In that sense, it's conceptually closer to the traditional Christian path from Creation to Conflagration than Buffon might have preferred. Many geologists who did not accept Buffon's cosmogony nevertheless viewed earth's history as progressive.

The Huttonians should have been thankful that Buffon provided a source of internal heat necessary to the workings of the earth's cyclical processes. But they couldn't accept Buffon's theory because the Huttonian earth required a *constant* source of internal heat, not one that decreased over time. This constant heat was essential for the cycles of erosion, accumulation, and uplift to continue to function in equilibrium. The Huttonian cosmology is cyclical, and therefore directly in conflict with Buffon's cooling earth.

In 1796, Buffon's cosmogony was challenged (and eventually eclipsed) by an alternative explanation of the origins of the earth and other planets.

Chapter 3 of this book introduced Pierre-Simon Laplace's popular *Exposition du système du monde*, published in year 4 of the French Republic and later translated into English as *System of the World*. This is where Laplace describes the sinusoidal motion of the tides and shows how the gravitational effects of the sun and moon interact to form the characteristic pattern of neap tides and spring tides during the lunar month.

More mainstream historians of science remember Laplace's book much more for its very last chapter, innocently entitled "Considerations relative to the System of the World, and on the future Progress of Astronomy." This chapter abandons the strict adherence to facts and figures that characterizes Laplace's work to engage in speculation. Like Newton and Buffon, Laplace examines the uniform movement of the planets and moons around the sun. He finds that the odds of this happening by chance are 1 in 2 to the 29th power, or 536,870,912.[105] That is considerably more unlikely than Buffon's calculation of 1 in 7,962,624. Clearly, Laplace says, this is not coincidence. "A phenomenon so extraordinary, is not the effect of chance, it indicates an universal cause, which has determined all these motions."[106]

Laplace ponders Buffon's theory of planetary origins, but he finds that it doesn't account for the revolution of the various moons. He instead proposes something quite different: "that the atmosphere of the Sun originally extended beyond the orbits of all the planets, and that it has gradually contracted itself to its present limits."[107] Planets, he writes,

---

[105] Pierre-Simon Laplace, *The System of the World*, trans. J. Pond, Vol. II, London: Richard Phillips, 1809, https://books.google.com/books?id=f7Kv2iFUNJoC, p. 358. The English translation somewhat mangles the figure, but it's evident in the original French: Pierre-Simon Laplace, *Exposition du système du Monde*, Paris: IV, https://books.google.com/books?id=H7MWAAAAQAAJ, p. 297.
[106] Laplace, *The System of the World*, pp. 356–7.
[107] Ibid, p. 363.

> have been formed at the successive bounds of this atmosphere, by the condensation of zones, which it must have abandoned in the plane of its equator, and in becoming cold have condensed themselves towards the surface of this luminary…. One may likewise conjecture, that the satellites have been formed in a similar way by the atmosphere of the planets.[108]

As in Buffon's theory, the planets are cooling from an initial hot state, so Laplace's conjectures also imply a heat source internal to the earth.

In later editions of his *Exposition du système du monde*, Laplace began incorporating William Herschel's work on nebulas into his narrative of the formation of the Solar System. Just as Herschel saw nebulas as nascent collections of stars, Laplace envisioned the formation of the Solar System as a condensing nebula on a smaller scale.

Laplace had spent his entire career becoming the ultimate Newtonian in refining and extending Newton's principles to reveal the mathematical underpinnings of the world, and now he had refuted Newton's natural theological arguments about the nature of the Solar System. By this time, writers on natural theology had nearly abandoned astronomy and focused instead on arguments based on the complexity and adaptation of living things. William Paley devoted only one chapter of his *Natural Theology* to astronomy, and that chapter begins "My opinion of Astronomy has always been, that it is *not* the best medium through which to prove the agency of an intelligent Creator" other than a demonstration of "the magnificence of his operations."[109]

One of the assumptions of natural theology is that God made the world for humans. The absence of fossil remains of earlier humans seemed to confirm tradition and the sacred writings that humans have only been around for several thousand years. Yet, if the earth were as old as geologists were concluding, why would millions of years of preparation be needed before people could exist on it? What was going on during this vast expanse of time?

In 1796, the implications of these questions became deeper and more complex. An elephant was involved.

The 26-year-old Georges Cuvier sprang up "like a mushroom" according to one of his colleagues.[110] He had only recently begun working at Buffon's old institution, but it was no longer known as the Jardin du Roi. The Roi had been executed a few years previously, and the Jardin had been reorganized under the French Republic as the Muséum d'Histoire Naturelle. It's not quite clear what kind of career Cuvier expected in the relatively staid field of comparative anatomy, but he had a knack for analyzing bones.

In his first public lecture, Cuvier took on the elephant. It was well known at the time that despite the many differences between the African elephant and the Asian

---

[108] Ibid, pp. 364–5.
[109] William Paley, *Natural Theology: Or, Evidences of the Existence and Attributes of The Deity, Collected from the Appearances of Nature* (London: R. Faulder, 1802), https://books.google.com/books?id=aBteAAAAcAAJ, p. 409.
[110] Rudwick, *Earth's Deep History*, p. 108.

elephant, natural historians "have always regarded them as forming one and the same species." However, after having acquired skulls of these two types of elephants as one of the benefits of France's recent military conquests, Cuvier disagreed:

> A glance at these skulls is sufficient to observe, in their profile and all their proportions, differences that do not allow them to be regarded as the same species…. It is clear that the elephant from Ceylon differs more from that of Africa than the horse from the ass or the goat from the sheep.

Cuvier then considers the "bones of elephants … found underground in Siberia, Germany, France, Canada, and even Peru." Some people had speculated that these were Asian elephants used in military campaigns by Hannibal and others, while Buffon believed that as the earth cooled, elephants of the northern climates had migrated south. But now Cuvier establishes these fossil elephants as a different species. "These animals thus differ from the elephant as much as, or more than, the dog differs from the jackal and the hyena."

Cuvier's conclusion would color the rest of his career and the upcoming century of geology:

> All these facts, consistent among themselves, and not opposed by any report, seem to me to prove the existence of a world previous to ours, destroyed by some kind of catastrophe. But what was this primitive earth? What was this nature that was not subject to man's dominion? And what revolution was able to wipe it out, to the point of leaving no trace of it except some half-decomposed bones?[111]

Previously when fossils had been found that did not correspond exactly to living species, extinction was sometimes suggested, as the Rev. James Douglas had done in 1785. But nobody could know for sure. Many of these unusual fossils were from the sea, and it's possible that they were of a still living species as yet unknown to us.

But an elephant? If a living species of elephant still roamed northern Europe, we would know about it.

Cuvier had established the fact of extinction. This was not an easy concept within the context of natural theology. It implied that God had created a species of animal apparently in an era before the existence of humans, only to allow it to be extinguished. Why? And what about the existing species of elephants? Were they created at the same time as the extinct elephants, or later, after the "catastrophe" or "revolution" of which Cuvier speaks?

Cuvier next took on a fossil found in Paraguay, "twelve feet long and six in height." He reported: "This animal differs, in the ensemble of its characters, from all known animals; and each of its bones, considered separately, also differs from the equivalent bones

---

[111] All quotations from "Memoir on the Species of Elephants, Both Living and Fossil," in Martin J.S. Rudwick, *Georges Cuvier, Fossil Bones, and Geological Catastrophes: New Translations & Interpretations of the Primary Texts* (University of Chicago Press, 1997), pp. 18–24.

of all known animals." Cuvier classified this extinct animal as related to sloths and armadillos. He called it *Megatherium*.[112]

By 1798, Cuvier was already referring to "revolutions" rather than a single "revolution," for he had determined that various fossils belonged to different eras. He had begun formulating what would become his life's work:

> There is no longer anyone who does not know that the earth we inhabit shows everywhere clear traces of large and violent revolutions; but it has not yet been possible to unravel the history of these upheavals, despite the efforts of those who have collected and compared their documentation.[113]

He soon referred to one fossil marsupial as perhaps buried for *milliers de siècles* — thousands of centuries.[114]

Cuvier collaborated with mining engineer Alexandre Brongniart in an extensive investigation of the strata in the Paris region. They described nine formations, each containing different characteristic fossils, all associated with pre-human eras. In some cases, the beds were distinct; in others "the fossils characteristic of one bed become less numerous in the higher one, and disappear altogether in the others, where they are replaced little by little by new fossils that had not appeared at all before."[115] This research led to a colored geological map of the area in 1808, the first such map of its kind.

Or was it? During a visit to London in 1802, Brongniart likely saw an early draft of William Smith's famous map[116] — the map that author Simon Winchester chronicles in his book *The Map that Changed the World*, and which has sometimes earned William Smith the title of the "father of English geology." Smith's map wasn't published until 1815, and it covered a much wider area than the Paris map, encompassing most of Great Britain. Smith was not a theorist and he devised no grand histories of the earth, but in his geological surveys he became extremely skilled in identifying and differentiating strata by the fossils imbedded within.

The natural theological design argument held that each species is ideally adapted to its environment because it was specifically designed for a particular setting and the overall chain of life. But what happens when the environment changes? Cuvier thought environmental changes occurred as catastrophic events. This is what caused extinction and (more mysteriously) the replacement with other species. Species themselves were fixed. They could not change except in very limited adaptations.

One of Cuvier's colleagues at the Muséum d'Histoire Naturelle was much more skeptical about extinction, and he did not accept the fixity of species.

---

[112] "Skeleton found in Paraguay," Rudwick, *Georges Cuvier*, pp. 27–32.
[113] Ibid, p. 35.
[114] Ibid, p. 70.
[115] Ibid, p. 143.
[116] Rudwick, *Georges Cuvier*, p. 129, fn 1.

Jean-Baptiste Lamarck was 25 years older than Cuvier, and old enough to have been helped by Buffon in his early career.[117] His scientific interests included botany, physics, and chemistry, but at the Muséum, Lamarck gravitated towards the classification of species, and what that implied about their origins.

Lamarck first unveiled his theory about the development of species in 1800 as the opening lecture of a course he gave at the Muséum on invertebrates (animals without a backbone).[118] He cites how changes in climate and other living conditions might create situations in which animals are no longer suited for their environment. They respond by adopting different habits:

> Now consequent upon these different influences the faculties are widened and strengthened by use, they are changed by new habits maintained for a long time; and gradually the conformation, consistence, the nature and state of the parts of organs, affected by the results of all these influences, are conserved and are spread by reproduction.[119]

These new habits then become inherited by each succeeding generation. Lamarck's favorite examples describe how birds adapt to different environments:

> The bird, attracted by need to water in search of prey on which to live, spreads the digits of its feet when it wants to strike the water and to move across the surface. The skin, which joins these digits at their base thus gets the habit of stretching. So in time the large membranes joining the digits of ducks, geese, etc. were formed as we now see them.[120]

Other birds need to perch on trees. Their toes are stretched differently so that they can grip the branches. These changes are then passed to their descendants. Lamarck was then (and is still now) often accused of suggesting that the animals exhibit conscious choice or desire in altering their bodies, but this is not so: For Lamarck, the physiological changes arise solely from the adoption of different habits.[121]

Lamarck knew that many people believed "that the earth has suffered a universal upheaval, a general catastrophe, as a result of which many diverse species of animals and plants are now absolutely lost or destroyed."[122] He denies this. The difference between fossil shells and the shells of current species "does not prove in any way that the species of these shells are extinct, but only that they have changed in the course of time, and that

---

[117] Ludmilla Jane Jordanova, *Lamarck* (Oxford University Press, 1984), p. 4. This short book is the source of most of the biographical information about Lamarck here.
[118] An English translation was published as "Lamarck in 1800," *Annals of Science* (Vol. 8, 1952), pp. 229–254, and was reprinted in J. B. Lamarck, *Zoological Philosophy* (University of Chicago Pres, 1984), pp. 407–433. Subsequent footnotes cite pages numbers from both sources.
[119] Ibid, p. 237; p. 414.
[120] Ibid, p. 237; p. 415.
[121] Jordanova, *Lamarck*, pp. 55, 102.
[122] "Lamarck in 1800," p. 252; p. 432.

contemporary ones have forms that differ from those of the individuals whose fossil remains we find."[123]

Lamarck's 1809 treatise *Philosophie Zoologique* discusses his theory in more depth and with more boldness and confidence. Published when he was 65 years old — and in the year of Charles Darwin's birth — *Philosophie Zoologique* begins with Lamarck's categorization of the entire animal kingdom. As had been traditional since Aristotle, Lamarck begins with the most sophisticated mammals and proceeds towards the simplest. He claims that these categories are not inherent in nature but constructed for the benefit of naturalists. When this progression is flipped upside down, we see an almost continuous progression from the simplest creatures to the most complex.

Lamarck finds that organisms have an innate capacity to increase in sophistication and complexity over the generations as well as to react to changing environmental conditions: "after a long succession of generations these individuals, originally belonging to one species, become at length transformed into a new species distinct from the first."[124] Lamarck repeats his example of the birds as well as the animal now most closely associated with his theory:

> It is interesting to observe the result of habit in the peculiar shape and size of the giraffe (*Camelo-pardalis*): this animal, the largest of the mammals, is known to live in the interior of Africa in places where the soil is nearly always arid and barren, so that it is obliged to browse on the leaves of trees and to make constant efforts to reach them. From this habit long maintained in all its race, it has resulted that the animal's fore-legs have become longer than its hind legs, and that its neck is lengthened to such a degree that the giraffe, without standing up on its hind legs, attains a height of six metres (nearly 20 feet).[125]

In several pages that begin with the heading "Quelques Observations relatives à l'Homme"[126] ("Some Observations with regard to Man"[127]), Lamarck speculates how "some race of quadrumanous animals" (he later mentions the orang) might begin to stand on two feet "to command a large and distant view." They might give up their jaws "for biting, tearing or grasping" and begin using them for "the formation of articulate sounds." These are some of the habits that would cause this quadrumanous animal to become more human. But even Lamarck is not ready to go that far, and he coyly concludes

---

[123] Ibid, p. 253; p. 432.
[124] J. B. Lamarck, *Zoological Philosophy*, trans. Hugh Elliot (London: Macmillan, 1924), https://books.google.com/books?id=el47AAAAYAAJ, p. 39
[125] Lamarck, *Zoological Philosophy*, p. 256.
[126] J. B. Lamarck, *Philosophie Zoologique*, Volume I (Paris: Dentu, 1809), https://books.google.com/books?id=vUIDAAAAQAAJ, p. 349.
[127] Lamarck, *Zoological Philosophy*, p. 169.

> Such are the reflections which might be aroused, if man were distinguished from animals only by his organization, and if his origin were not different from theirs.[128]

The biological mechanism behind these transformations was more vague. Lamarck believed that it was inherent part of life, which he attributed to subtle fluids that include caloric (the substance of heat) and electricity. Lamarck makes no attempt to explain how characteristics acquired during the lifetime of an organism are passed through inheritance to its offspring.

The French came to refer to Lamarck's theory as *transformisme* because one species gradually transforms into another. The British tended instead to refer to the *transmutation* of species — a word more closely associated with the discredited science of alchemy.[129] Words have power, and just as modern British men of science knew that one element couldn't be transmuted into another, most of them were equally confident that species couldn't do it either — particularly in the godless materialistic manner that Lamarck described.

Lamarck's theory got less love in Britain than in France, but it didn't get much love in France either, and particularly not from Cuvier. Cuvier summed up his thoughts about the succession of living things in 1812 in a preliminary discourse to the four-volume *Recherches sur Les Ossemens Fossiles de Quadrupèdes*, which reprinted all of Cuvier's researches on quadruped fossil bones, with a dedication to Laplace.

Cuvier begins by calling himself "a new species of antiquarian" and puts his work in the context of other great scientific achievements:

> We admire the power by which the human spirit has measured the movements of the globes, which nature seemed to have concealed forever from our view; genius and science have burst the limits of space, and some observations developed by reason have unveiled the mechanism of the world. Would there not also be some glory for man to know how to burst the limits of time, and by some observations, to recover the history of the world, and the succession of events that preceded the birth of the human species?[130]

Ever since, readers have latched onto that phrase "burst the limits of time" to describe the progress of geological science during this period.

Cuvier's researches into fossils had convinced him of the succession of a series of events that destroyed entire species:

> Thus life on earth has often been disturbed by terrible events: calamities which initially perhaps shook the entire crust of the earth to a great depth, but which have since become steadily less deep and less general. Living organisms without

---

[128] Ibid, pp. 170, 173.
[129] Rebecca Stott, *Darwin's Ghosts: The Secret History of Evolution* (NY: Spiegel & Grau, 2012). P. 185.
[130] Rudwick, *Georges Cuvier*, p. 185

> number have been the victims of these catastrophes. Some were destroyed by deluges, others were left dry when the seabed was suddenly raised; their races are even finished forever, and all they leave in the world is some debris that is hardly recognizable to the naturalist…. But what is still more astonishing, and no less certain, is that life has not always existed on the globe, and that it is easy for the observer to recognize the point at which it began to deposit its products.[131]

What Cuvier does not describe is how new species arise to replace those that are destroyed. He was content to leave that as something of a mystery, or perhaps was reluctant to attribute new species to a miracle of creation.

As a comparative anatomist Cuvier realized that all the parts of an organism were intricately connected, and that a change in one part would cause a disruption of the harmony of other parts:

> Every organized being forms a whole, a unique and closed system, in which all the parts correspond mutually, and contribute to the same definitive action by a reciprocal reaction. None of its parts can change without the others changing too; and consequently, each of them, taken separately, indicates and gives all the other.[132]

This is how anatomists can extrapolate from a single fossil bone many of the characteristics of the rest of the animal.

This intricate interrelationship between all the parts of an organism became one of the major refutations of Lamarck's assumption that a single organ can change based on habit. Cuvier has other objections to Lamarck: The fossil record should reveal when species have been modified based on local circumstances and climate change: "if species have changed by degrees one ought to find some traces of these gradual modifications." That no evidence has been found indicates that "the species of former times were as constant as ours."[133]

Cuvier had also examined the mummies of people and animals taken from Egypt by Geoffroy Saint-Hilaire. "He brought back cats, ibis, birds of prey, dogs, monkeys, crocodiles, and one ox's head," and none of these showed any differences from species that now exist. For better or for worse, modern-day cats are the same as Egyptian cats. Nor could many of the more exotic fossils that Cuvier examined — "the *palaeotheriums*, the *anoplotheriums*, the *megalonyxes*, the *mastodons*, the *pterodactyles*, etc."[134] — possibly be the ancestors of anything currently roaming the earth.

Cuvier further reports that no human fossils have ever been found: "From this it is clear that no argument in favor of the antiquity of the human species in these various countries

---

[131] Ibid, p. 190.
[132] Ibid, p. 217.
[133] Ibid, p. 226.
[134] Ibid, p. 229.

can be drawn, either from the bones themselves or from the more or less considerable masses of stones and earth that cover them."[135]

Apart from the numerous fossils of species that no longer exist and which must have been extinguished in several cataclysms, Cuvier identifies a rather special event in earth's history that he avoids specifying precisely: "the surface of our globe has been the victim of a great and sudden revolution, the date of which cannot reach back much more than five of six thousand years." The few survivors "spread out and reproduced … and that consequently it is only since that time that our societies have resumed a progressive course, that they have formed institutions, erected monuments, collected facts of nature, and combined them into scientific systems."[136]

When an English translation of Cuvier's Preliminary Discourse appeared in 1813, it was called *Essay on the Theory of the Earth* — not a title Cuvier would likely have approved — and embellished with a Preface and Notes by Robert Jameson, the Regius Professor of Natural History at the University of Edinburgh. (Later on, Charles Darwin would be one of Jameson's pupils.) Only five pages in length, this Preface begins with a reference to Genesis:

> Although the Mosaic account of the creation of the world is an inspired writing, and consequently rests on evidence totally independent of human observation and experience, still it is interesting, and in many respects important, to know that it coincides with the various phenomena observable in the mineral kingdom.

The focus on Genesis doesn't let up:

> Even the periods of time, the six days of the Mosaic description, are not inconsistent with our theories of the earth. There are, indeed, many physical considerations which render it probable that the motions of the earth may have been slower during the time of its formation than after it was formed, and consequently that the day, or period between morning and evening, may have been indefinitely longer than it is at present.…
>
> The deluge, one of the grandest natural events described in the Bible, is equally confirmed, with regard to its extent and the period of its occurrence, by a careful study of the various phenomena observed on and near the earth's surface.…
>
> These enquiries, particularly what regards the deluge, form a principle object of the Essay of Cuvier, now presented to the English reader….
>
> Subjects so important, and treated by one of the first philosophers of the age … admonish the skeptic, and afford the highest pleasure to those who delight in

[135] Ibid, p. 234.
[136] Ibid, p. 248.

> illustrating the truth of the Sacred Writings, by an appeal to the facts and reasonings of natural history.[137]

This Preface put a decidedly more religious spin on Cuvier's Preliminary Discourse than is present in the original. Consequently, for English readers, Cuvier acquired a reputation as a strong defender of Genesis, when in truth he was not nearly as adamant as this Preface implied. Beginning with the 3rd edition of *Essay on the Theory of the Earth* in 1817, Jameson removed much of the religious content of the Preface, but the reference to the Deluge remained.

For the most part, however, the focus in Great Britain had shifted to a more empirical and investigative approach to geology. In 1807, the Geological Society of London was founded with a goal to establish an association of "gatherers of facts" and not get involved with "fanciful 'theories of the Earth'." Yet, the Geological Society was unique in that it allowed extensive discussion of papers following their readings, and these could become quite heated and acrimonious. Said one observer of these encounters, "Though I don't care for geology, I do like to see the fellows fight."[141] The Geological Society remains today the oldest geological society in the world.

In 1813, "the first genuinely popular text"[142] on geology appeared: Robert Bakewell's *An Introduction to Geology*.[143] Bakewell was by trade a surveyor who apparently educated himself in the sciences later in his life, not publishing his book on geology until he was 45. Divided into self-contained sections, light on theory and polemics, and with numerous examples from the landscape of Great Britain, Bakewell's was the first book that made geology palatable for the general reader. His descriptions of ancient ages can still elicit a flurry of romantic excitement:

> The fossil remains of animals not now in existence, entombed and preserved in solid rocks, present us with durable monuments of the great changes which our planet has undergone in former ages. We are led to a period when the waters of

---

[137] Georges Cuvier, *Essay on the Theory of the Earth*, trans. Robert Kerr, introduction and notes by Robert Jameson (Edinburgh: William Blackwood, 1813), http://lhldigital.lindahall.org/cdm/ref/collection/earththeory/id/4231, Preface, p. v–ix.
[138] William Hanna, *Memoirs of the Life and Writings of Thomas Chalmers, D.D. LL.D*, Vol 1, Edinburgh: Sutherland and Knox, 1849, https://books.google.com/books?id=xVgEAAAAQAAJ, pp. 80–81.
[139] Thomas Chalmers, *The Evidence and Authority of the Christian Revelation*, Fourth Edition, Edinburgh: William Blackwood, 1817, https://archive.org/details/evidenceandautho00chaluoft, pp. 204–5.
[140] *The Edinburgh Encyclopœdia*, Volume VI, Edinburgh: William Blackwood, 1830, https://babel.hathitrust.org/cgi/pt?id=chi.31966664. The article on "Christianity" is pages 355 through 396; the article on "Chronology" begins on page 402.
[141] quoted in John C. Thackray, ed., *To See the Fellows Fight: Eyewitness accounts of meetings of the Geological Society of London and its Club, 1822–1868* (The British Society for the History of Science, 2003)a. Quotations are from the Introduction, pp. v–xii.
[142] Porter, *The Making of Geology*, p. 211.
[143] Robert Bakewell, *An Introduction to Geology* (London: J. Harding, 1813), https://books.google.com/books?id=8SpKvAEACAAJ..

> the ocean have covered the summits of our highest mountains, and are irresistibly compelled to admit one of two conclusions, either that the sea has retired and sunk below its former level, or some power operating from beneath has lifted up the island and continents, with all their hills and mountains, from the watery abyss to their present elevation above its surface. We are also led to infer that great revolutions have taken place at distant periods of time.[144]

Or:

> What various reflections crowd upon the mind, if we carry back our thoughts to the time when the whole surface of the globe was agitated by tumultuous and conflicting elements; or to the succeeding intervals of repose, when all was one vast solitude; and again to a subsequent period, when the deep silence of nature was broken by the bellowings of the great mastodon and the mammoth, who stalked the lords of the creation, and perished in the last grand revolution of the globe before the formation of time![145]

The second enlarged edition of Bakewell's *Introduction* published in 1815[146] happened to have a prominent role in the history of geology, for this is the edition that the teenage Charles Lyell discovered in his father's library during a vacation break from his first year at Oxford. It changed his life.

Lyell was going to college at a time when both of England's most prestigious universities had acquired professors of geology who would also make strong imprints on its history: Adam Sedgwick at Cambridge and William Buckland at Oxford. Both men would eventually serve as presidents of the London Geological Society, and (as was common at the time) both were ordained priests in the Church of England.

Adam Sedgwick became the Woodwardian Professor of Geology at Cambridge in 1818. This was the seat founded after the 1728 death of John Woodward, author of the 1695 book *An Essay toward a Natural History of the Earth* that attributed the earth's strata to a settling after the Deluge. Sedgwick would occupy this position for some fifty years, during which time the young Charles Darwin would be one of his students. During his tenure he contributed so much to the Woodwardian Museum of fossils that a new museum was created and named after Sedgwick.

At Oxford, William Buckland was elected reader in mineralogy in 1813, and then a new readership in geology was endowed for him in 1818. Buckland is certainly the most colorful figure in geology, well known for his flamboyant lecturing style, "dashing down amongst us ever and anon to enforce an intricate point with Samsonic wielding of a cave-bear jaw or a hyæna thigh bone." He kept live animals around his house and put cooked ones on the dinner table: "horseflesh I remember more than once, crocodile another day, mice baked in

---

[144] Ibid, pp. 16–17.
[145] Ibid, pp. 326–327.
[146] Robert Bakewell, *An Introduction to Geology*, 2nd edition (London: J. Harding, 1815), https://books.google.com/books?id=pAgAAAAAQAAJ.

batter on a third." He seemed to be eating his way through the animal kingdom. Buckland was the subject of many anecdotes:

> [Buckland's son] Frank used to tell of their visit long afterwards to a foreign cathedral, where was exhibited a martyr's blood — dark spots on the pavement ever fresh and ineradicable. The professor dropped on the pavement and touched the stain with his tongue. "I can tell you what it is: it is bat's urine!"[147]

More importantly, Buckland serves as an interesting case study of the changing ideas in geology during the 1820s and 1830s. Buckland was courageous enough to publicly acknowledge a change in his views when the evidence convinced him that he had been wrong.

On his appointment to the new readership in geology, Buckland presented an inaugural address in 1819 entitled *Vindiciæ Geologiæ; or the Connexion of Geology with Religion Explained*. The intent of Buckland's "vindication of geology" was to allay the fears of those who believed that the subject led to religious skepticism. Buckland instead demonstrates how geology supports both natural theology and revelation.

Early in this address, Buckland cites Cuvier as "one of the most enlightened Philosophers, and the greatest Anatomist of this or any other age" and quotes from the conclusion of Cuvier's Preliminary Discourse (which he refers to by the title of its English translation, *Essay on the Theory of the Earth*) praising those who "have the glory of restoring the history of thousands of ages which preceded the existence of his race, and of thousands of animals that never were contemporaneous with his species."[148] This is how Buckland effectively announces his conviction that the earth is very old.

Some may have wondered why a world made specifically for humans existed so long without any humans at all. Buckland finds an explanation in natural theology: Those long preliminary periods of the earth were necessary for the beneficial distributions of minerals, metals, salt, and fuel, and particularly for

> the vast repositories of coal to be accumulated from the wreck and ruins of disturbances that affected our planet long before the existence of the human race; … in all these and a thousand other examples that might be specified of design and benevolent contrivance, we trace the finger of an Omnipotent Architect providing for the daily wants of its rational inhabitants, not only at the moment in which he laid the first foundations of the earth, but also through the long series of shocks and destructive convulsions which he has caused subsequently to pass over it.[149]

---

[147] Rev. W. Tuckwell, *Reminiscences of Oxford*, London: Cassell and Company, 1900, https://books.google.com/books?id=BwMxAAAAYAAJ, pp. 38, 39, 40.
[148] William Buckland, *Vindiciæ Geologiæ; or the Connexion of Geology with Religion Explained* (Oxford: University Press, 1820), pp. 5, 6.
[149] Ibid, p. 12.

Despite his acceptance of an old age of the earth, Buckland wished to preserve as much of Genesis as he could: "though Moses confines the detail of his history to the preparation of this globe for the reception of the human race, he does not deny the prior existence of another system of things, of which it was quite foreign to his purpose to make mention, as having no reference to the destiny or to the moral conduct of created man."[150] Where the chronology of Genesis is still undeniably valid regards the creation of humans: "*the existence of mankind* can on no account be supposed to have taken its beginning before that time which is assigned to it in the Mosaic writings."[151]

Buckland was particularly interested in the geological evidence of a massive flood that left its scars on the face of the earth:

> the grand fact of *an universal deluge* at no very remote period is proved on grounds so decisive and incontrovertible, that, had we never heard of such an event from Scripture, or any other authority, Geology of itself must have called in the assistance of some other catastrophe, to explain the phenomena of diluvian action which are universally presented to us, and which are unintelligible without recourse to a deluge exerting its ravages at a period not more ancient than that announced in the Book of Genesis.[152]

Soon after this inaugural address, Buckland had the opportunity to examine a large collection of fossil bones found in Kirkdale Cave in Yorkshire. The initial assumption was that the animals had either been trapped in the cave during the Deluge, or the Deluge had washed their drowned carcasses into the cave. The results of Buckland's researches were presented to the Royal Society in 1822 and became highly celebrated, forming the first part of Buckland's 300-page book *Reliquiæ Diluvianæ; or, Observations on the Organic Remains contained in Caves, Fissures, and Diluvial Gravel, and on Other Geological Phenomena, Attesting the Action of a Universal Deluge*.

Except that the bones in Kirkdale Cave were *not* "relics of the Deluge." Instead, as Buckland wrote, "the cave at Kirkdale was, during a long succession of years, inhabited by a den of hyænas, and that they dragged into its recesses the other animal bodies whose remains are found mixed indiscriminately with their own."[153] These included tiger, bear, wolf, fox, weasel, elephant, rhinoceros, hippopotamus, horse, ox, and deer,[154] many of which were of species now extinct. In those cases where the animals were so large that they could not have been killed or dragged by hyenas, Buckland suggests that they had died naturally, and then been dismembered and dragged to the cave. Buckland has no doubt that this hyena den was maintained prior to the Deluge, but that the mass destruction of these animals was not a result of the Deluge.

---

[150] Ibid, p. 24–25.
[151] Ibid, p. 23.
[152] Ibid, p. 23–4.
[153] William Buckland, *Reliquiæ Diluvianæ* (London: John Murray, 1823), https://books.google.com/books?id=VsoQAAAAIAAJ (2nd edition, same pagination), p. 19.
[154] Ibid, table following contents.

Buckland's analysis of the Kirkdale Cave was a spectacular piece of detective work that used comparative anatomy and a forensic inspection of bones and fossilized feces to recreate an ancient hyena den and give a glimpse into the pre-human past. Nothing like it had ever been done before.[155] But it hardly demonstrated the cave to be a relic of the Deluge. Throughout *Reliquiæ Diluvianæ*, Buckland sees evidence of the Deluge, but it is of a more subtle and less dramatic sort, and some of his readers were confused. As Buckland's modern biographer writes (without making it any less confusing), "The title was not so much a summery or conclusion of the book's contents as their disguise or apology."[156] Or as one of Buckland's colleagues at Oxford versified,

> Some doubts were once expressed about the Flood,
> Buckland arose, and all was clear as — mud.[157]

Slowly the waters of the Deluge were receding from a starring role in the science of geology.

One of William Buckland's early students at Oxford was the young Charles Lyell, who had become interested in geology during the summer or winter break in 1816. As Lyell's sister-in-law later wrote in her chronicle of Lyell's life,

> Bakewell's 'Geology,' which he found in his father's library, was the first book which gave him an idea of the existence of such a science as geology, and something said in it about the antiquity of the earth excited his imagination so much that he was well prepared to take interest in the lectures of Dr. Buckland, Professor of Geology at Oxford, who was then at the height of his popularity. Lyell attended a course of these lectures and took notes of them.[158]

Books can be powerful things, and one inspirational book can have the power to trigger another. Fifteen years later, in 1831, when the 22-year-old Charles Darwin set sail on the HMS *Beagle*, he already had in hand the first volume of Charles Lyell's newly published *Principles of Geology*. Darwin's biographer writes:

> In one of the most remarkable interchanges in the history of science, Lyell's book taught Darwin how to think about nature. Without Lyell there would have been no Darwin, no intellectual journey, no voyage of the Beagle as commonly understood. His influence — and his impact — on the young traveller can hardly be overestimated.[159]

Charles Lyell's father intended for him to become a barrister, and his time at Oxford was supposed to be spent learning the classics in preparation for his legal training.[160] But

---

[155] O'Connor, *The Earth on Show*, p. 85ff.
[156] Nicholaas A. Rupke, *The Great Chain of History: William Buckland and the English School of Geology, 1814–1849* (Oxford University Press, 1983), p. 39.
[157] Tuckwell, *Reminiscences of Oxford*, p. 35.
[158] *Life, Letters and Journals of Sir Charles Lyell*, ed. Katherine Murray Lyell, Vol. I (London: John Murray, 1881), https://babel.hathitrust.org/cgi/pt?id=hvd.32044029902806, p. 32.
[159] Janet Browne, *Charles Darwin: Voyaging* (Princeton University Press, 1995), p. 186.
[160] For biographical information see Leonard G. Wilson, *Charles Lyell: The Years to 1841: The Revolution in Geology* (Yale University Press, 1972).

Bakewell's *Introduction to Geology* and the lectures of Buckland threw his whole life askew. Lyell continued to study law, but over the next decade he immersed himself in geological writings and "geologizing" excursions throughout Britain, France, Italy, and Sicily examining geological formations as well as fossil collections. During an 1824 visit to Lyme, on the southern coast of England, Lyell "witnessed the discovery of a superb skeleton of Ichthyosaurus vulgaria, by Miss Anning" — the celebrated fossil discoverer Mary Anning, who was 25 years old at the time. "It was perfect, save the tail, which a cart-wheel had passed over. It was two feet long."[161]

Lyell published his first article in 1824, and then in 1826 wrote a 34-page article for the *Quarterly Review* about recent advances in geology: "the number of facts and discoveries established by this science during an exceedingly brief period of time, are perhaps unprecedented in the whole history of physical inquiry."[162]

This article was ostensibly a review of a recent publication of the *Transactions of the Geological Society of London*, but it allowed Lyell to entice the readers with tales of large fossil mammals and reptiles, including a description "by Dr. Buckland, of the Megalosaurus of Stonesfield, another genus of fossil oviparous quadrupeds of prodigious magnitude."[163]

Regarding the effects of geological activity on the earth, Lyell ruminates "whether the causes now in action are, as Dr. Buckland has supposed, 'the last expiring efforts of those mighty disturbing forces which once operated;' or whether, as Hutton thought, they would still be sufficient in a long succession of ages to produce analogous results."[164] Reading between the lines, we might assume that Lyell has already made up his mind when he concludes that "it appears premature to assume that existing agents could not, in the lapse of ages, produce such effects as fall principally under the examination of the geologist."[165]

In 1827, Lyell got a copy of Lamarck's *Philosophie Zoologique*. After he "devoured" it, he wrote to one of his geologist friends that he evaluated the book as a lawyer might in assessing the arguments of opposing counsel:

> His theories delighted me more than any novel I ever read, and much in the same way, for they address themselves to the imagination, at least of geologists who know the mighty inferences which would be deducible were they established by observations. But though I admire even his flights, and feel none of the *odium theologicum* which some modern writers in this country have visited him with, I confess I read him rather as I hear an advocate on the wrong side, to know what can be made of the case in good hands. I am glad he has been courageous enough and logical enough to admit that his argument, if pushed as far as it must go, if

---

[161] *Life, Letter and Journals*, Vol. I, p. 153.
[162] [Charles Lyell], Review of Transactions of the Geological Society of London, *The Quarterly Review* (Vol. XXXIV, No. LXVIII, Sept. 1826), https://books.google.com/books?id=51ZEAQAAMAAJ, pp. 507–540, p. 507.
[163] Ibid, p. 523.
[164] Ibid, p. 517.
[165] Ibid, p. 518.

> worth anything, would prove that men may have come from the Ourang-Outang.[166]

It's possible that Lyell began thinking about writing his own book around that time.

Later that year Lyell met Mary Somerville, who had made the home she shared with her husband a gathering place for people of science and mathematics. Mrs. Somerville was still a few years away from publishing her most popular books on science, including *Mechanism of the Heavens* (a translation and reformulation of parts of Laplace's *Mécanique Céleste*) and *On the Connexion of the Physical Sciences*, but she was already part of the extensive network that Lyell was developing.

Lyell's research for his book combined his field excursions with massive amounts of reading. Lyell could read French, of course, but he also benefited by being "almost the only English speaking geologist to read Italian geological works in the early nineteenth century,"[167] discovering a wealth of Italian literature on geology that nobody else in England knew about. The crucial language that Lyell did not know was German, but in 1829 he began studying the language with assistance from his sisters, and he got to the point where he could read German geology texts for research.

The first volume of Charles Lyell's book was published in 1830, and the full title reveals his approach: *Principles of Geology, being an Attempt to Explain the Former Changes of the Earth's Surface, by Reference to Causes Now in Operation*.[168] If it wasn't clear from the title, the book's epigraph is a quotation from Playfair's *Illustrations of the Huttonian Theory of the Earth*, and it is James Hutton who emerges triumphant from Lyell's initial four-chapter survey of the pre-Lyell history of geology. In his *Principles*, Lyell refines Hutton's geology, identifies its flaws, provides many more examples, while largely discarding Hutton's natural theological trappings.

Like Hutton, Lyell is not interested in the origins of the earth. It's too distant and indiscernible. "The philosopher" instead recognizes "an undeviating uniformity" of geological activity and "rejects the fabulous tales of former ages, on the ground of their being irreconcilable with the experience of more enlightened ages."[169]

Although Lyell's earth exhibits a type of steady-state equilibrium, it is not static. Indeed, the frontispiece to this first volume is a drawing of the Temple of Serapis in southern Italy whose markings demonstrate that the land on which it stands has fallen and risen over the past two thousand years, so slowly and steadily that the towers remained standing. Lyell's earth undergoes tremendous changes, but none of these changes are the result of anything not seen in the world today, and there is no overall direction or progress. Lyell finds evidence for climate change, for example, but he does not attribute this to any gradual cooling of the earth as had been suggested by Buffon. Such cooling would have

---

[166] *Life, Letters and Journals*, Vol. I, p. 168.
[167] Wilson, *Charles Lyell: The Years to 1841*, p. 265.
[168] Charles Lyell, *Principles of Geology*, Vol. I (London: John Murray, 1830), https://babel.hathitrust.org/cgi/pt?id=nyp.33433066370341.
[169] Ibid, p. 76.

caused the earth to contract, and the length of the day to have become shortened; "on the contrary, La Place has shewn, by reference to astronomical observations made in the time of Hipparchus, that in the last two thousand years there has been no sensible contraction of the globe by cooling down."[170]

Instead, "all former changes of the organic and inorganic creation are referrible to one uninterrupted succession of physical events governed by the laws now in operation."[171] Lyell acknowledges the frequent observation that the strata seems to reflect a "progressive development of organic life"[172] from simple to complex: Strata with no organic remains are covered by strata with fossils of shells and plants, and then fishes, birds, and quadrupeds. Finally, man exists and there are no fossil remains to indicate an existence beyond a few thousand years.

Lyell spends a chapter[173] grappling with the idea that fossils exhibit a progressive tendency towards complexity. He cites anomalies such as fossils found where the theory of progressive development suggest they should not be. He laments incomplete data. And he concludes:

> "It is, therefore, clear, that there is no foundation in geological facts, for the popular theory of the successive development of the animal and vegetable world, from the simplest to the most perfect forms…"[174]

Lyell even quotes William Paley's *Natural Theology* in support of the continuity and unity of nature: "New countries are continually discovered, but the old laws of nature are always found in them … the same order of things attends us wherever we go."[175] The appearance of man is the only exception to the rule of continuity without progress.

Lyell even suggests that climate cycles might cause currently extinct species of animals to make a new appearance:

> Then might those genera of animals return, of which the memorials are preserved in the ancient rocks of our continents. The huge iguanodon might reappear in the woods, and the ichthyosaur in the sea, while the pterodactyle might flit again through umbrageous groves of tree-ferns.[176]

This was not a view held by many others! English geologist Henry Thomas De la Beche mocked the concept with a cartoon portraying Lyell as Professor Ichthyosaurus lecturing a

---

[170] Ibid, p. 141.
[171] Ibid, p. 144.
[172] Ibid, p. 145.
[173] Ibid, Ch. IX, pp. 144–166.
[174] Ibid, p. 153.
[175] Ibid, p. 159, quoting from William Paley, *Natural Theology: or, Evidences of the Existence and Attributes of the Deity, Collected from the Appearances of Nature* (London: R. Faulder,1802), https://books.google.com/books?id=aBteAAAAcAAJ, pp. 483–4.
[176] Ibid, p. 123.

class of reptilian students about the skull of an extinct human.[177] De la Beche was one of the first artists to portray *Scenes from Deep Time* (as the title of Martin Rudwick's book calls them) that became popular throughout the 19th century and remain so to the present day, presenting to both adults and curious children plausible glimpses into the distant past.

Just about a third of the way into the first volume of *Principles of Geology*, Lyell resolves the old dispute between the Neptunists and the Vulcanists rather anticlimactically by conceding a role to both water *and* fire:

> We may divide the great agents of change in the inorganic world into two principal classes, the aqueous and the igneous. To the former belong Rivers, Torrents, Springs, Currents and Tides; to the latter, Volcanos and Earthquakes. Both these classes are instruments of decay as well as of reproduction; but they may be also regarded as antagonist forces. The *aqueous* agents are incessantly labouring to reduce the inequalities of the earth's surface to a level, while the *igneous*, on the other hand, are equally active in restoring the unevenness of the external crust, partly by heaping up new matter in certain localities, and partly by depressing one portion, and forcing out another of the earth's envelope.[178]

The remainder of the volume is devoted to chronicling the unrelenting forces of nature — the "causes now in operation" referred to in the book's subtitle. These are sufficient to account for all the appearances of the natural world. Whole chapters are devoted to the action of running water, both destructive and productive, of tides and currents, as well as floods, but not a universal Deluge. Lyell stated privately that one of his goals in writing a book on geology was to "free the science from Moses,"[179] but he was really only bothered by the literalists who distorted their science to conform to Genesis.

In this first volume, Lyell restricts himself to recorded history, and usually just the past couple centuries, with numerous examples from Europe, North and South America, and Australia to demonstrate the very many ways that the earth can change by the constant influences of water and heat. Lyell devotes five chapters to volcanoes,[180] and concludes

> if we consider the active volcanos of Europe to constitute about a fortieth part of those already known on the globe, and calculate, that, one with another, they are about equal in activity to the burning mountains in other districts, we may then compute that there happen on the earth about two thousand eruptions in the course of a century, or about twenty every year.[181]

A modern estimate is about 50 to 60 eruptions per year.

---

[177] Martin J.S. Rudwick, *Scenes from Deep Time: Early Pictorial Representations of the Prehistoric World* (University of Chicago Press, 1982), p. 49.
[178] Lyell, *Principles of Geology*, Vol. I, p. 167.
[179] *Life, Letters and Journals*, Vol. I, p. 268.
[180] Lyell, *Principles of Geology*, Vol. I, chs. XVIII–XXII, pp. 312–398.
[181] Ibid, p. 397,

The final four chapters cover earthquakes,[182] with descriptions of 43 earthquakes over the past 140 years. Lyell concludes "as we have calculated that there are about twenty volcanic eruptions annually, we shall, perhaps, not overrate the earthquakes, if we estimate their number to be equal."[183] Actually, some half a million earthquakes occur every year, but most aren't even felt by people and only a few cause damage.

For Lyell's first readers, sitting perhaps in a quiet study overlooking a calm and tranquil English countryside, this book presented a shocking contrast to their daily experiences. Lyell describes a violent turbulent earth in a persistent state of flux, each flow of water and each jolt of the earth contributing to its destruction and renewal. Just 150 years earlier, Thomas Burnet's *Theory of the Earth* attributed all the mountains and seas to the Deluge breaking apart a pristine earth. Charles Lyell's vision was of a longer, more gradual, cyclic churning.

The most perceptive review of Volume I of *Principles of Geology* appeared in a London periodical with the forbidding title *The British Critic, Quarterly Theological Review, and Ecclesiastical Record*, which mostly ran reviews of religious-themed books and pamphlets, but also included notices of the Anglican clergy graduating from universities, obtaining preferments, getting married, and dying,

Although published anonymously like most reviews of this era, this review of *Principles of Geology* was known to have been written by William Whewell,[184] a priest in the Church of England who had served as professor of mineralogy at Trinity College, Cambridge since 1828. In his early thirties at the time, Rev. Whewell would soon come to reveal an extensive learning and erudition covering a broad range of science and philosophy. He would emerge as one of the towering intellects in British public life, and he knew it. "Science is his forte," it was said of Whewell, "omniscience his foible." (The pronunciation of Whewell's last name remains controversial. It is generally acknowledged that the initial W is mostly silent, and that the name rhymes with a two-syllable rendition of "jewel," but apparently the man himself pronounced it with an initial aspiration, suggesting a reason for his Cambridge nickname of Billy Whistle.)

Whewell had high praise for much of the content of Lyell's book: "there is no comparison in the fullness and variety of his facts, in the clear intelligence of their true nature and bearing, between this and any previous work of the kind." Lyell has "collected, combined and systematized in a very instructive manner," doing so much to elevate these descriptions of geological processes into a separate science that a new term was appropriate: "a science which has for its object to classify and analyse the changes which are perpetually occurring in the inorganic portion of nature: and which we might call

---

[182] Ibid, chs. XXIII—XXVI, pp. 399–479.
[183] Ibid, p. 474.
[184] [William Whewell], Review of *Principles of Geology* Vol. I, *The British Critic, Quarterly Theological Review, and Ecclesiastical Record*, Vol. IX, No. XVII (Jan., 1831), https://books.google.com/books?id=XugqAAAAYAAJ, pp. 180–206.

GEOLOGICAL DYNAMICS, since it treats of the forces which are acting to modify the face of the earth."[185] This would not be Whewell's last neologism. He had a knack for it.

Yet, Whewell remained quite skeptical about Lyell's main contention of the strict uniformity of natural processes:

> It appears to us, then, that even taking into account the mechanical changes alone, of which the earth's surface tells the tale, we cannot reconcile them with the uniform course of nature which Mr. Lyell inculcates. And it seems to be in vain that he has endeavored to embody in material realities the arbitrary and fanciful visions of recurring cycles of mundane events …[186]

He also challenges Lyell to "supply us with some mode by which we may pass from a world filled with one kind of animal forms, to another, in which they are equally abundant, without perhaps one species in common."[187] This was next in Lyell's plans.

Principles of Geology was originally supposed to be two volumes, but by the end of 1831, Lyell had written so much that it was decided to publish a shorter second volume in January 1832[188] and save the rest for Volume III.

As Volume I covered "causes now in operation" of water and heat, Volume II focused on the organic world of living things. Lyell treats the inorganic and organic realms as interdependent: Climate and geology affect living things, but living things also contribute to geology, most obviously by becoming chalk (the remnants of seashells) or coal (decayed vegetation).

But first, Lyell had to take on Lamarck. He devotes the first four chapters of Volume II to a basic question: "whether species have a real and permanent existence in nature; or whether they are capable, as some naturalists pretend, of being indefinitely modified in the course of a long series of generations?"[189] In his extensive discussion of Lamarck's theories, one scholar has noted that Lyell "inadvertently acted as Lamarck's publicist, producing by far the most comprehensive and accurate summary of Lamarckian ideas produced in England up to that date."[190]

Lyell generally uses the word *transmutation* to describe Lamarck's theories of species change, but on two occasions he uses a different word: Lyell says of Lamarck's speculations that "the Testacea of the ocean existed first, until some of them, by gradual evolution, were *improved* into those inhabiting the land." Later he alludes to "the fancied

---

[185] Ibid, pp. 186, 198, 195.
[186] Ibid, pp. 203.
[187] Ibid, p. 194.
[188] Charles Lyell, *Principles of Geology*, Vol. II (London: John Murray, 1832), https://babel.hathitrust.org/cgi/pt?id=nyp.33433066370358.
[189] Ibid, p. 1.
[190] Pietro Corsi, "The Importance of French Transformist Ideas for the Second Volume of Lyell's Principles of Geology," *The British Journal for the History of Science*, Vol. 11, No. 39 (1978), pp. 221–244, p. 231.

evolution of one species out of another."[191] These are apparently the first times the word *evolution* had been used in this sense. In retrospect, Lyell's statement that "In the universal struggle for existence, the right of the strongest eventually prevails"[192] is also interesting.

While Lyell may not agree with Cuvier about historical catastrophic transitions in geological history, he's with Cuvier in his rejection of Lamarck. He finds "no support whatever to the notion of a gradual transmutation of one species into another" and concludes "that species have a real existence in nature, and that each was endowed, at the time of its creation, with the attributes and organization by which it is now distinguished."[193]

Lyell speaks of how "in a state of nature, a newly-created species might spread itself, in every direction, from a single point."[194] In a similarly speculative manner, Lyell also writes:

> Each species may have had its origin in a single pair, or individual, where an individual was sufficient, and species may have been created in succession at such times and in such places as to enable them to multiply and endure for an appointed period, and occupy an appointed space on the globe.[195]

But he never gets more explicit about how the creation of new species takes place.

The process of extinction is rather simpler, and "the successive destruction of species must now be part of the regular and constant order of Nature." A species can become extinct when the climate changes, or when its living conditions otherwise change, or when it is entirely consumed by predators, or even hunted by man. Lyell cites several animals once common on the British Isles that have now been "extirpated," including the beaver, wolf, and bear. "Man is, in truth, continually striving to diminish the natural diversity of the stations of animals and plants in every country, and to reduce them all to a small number fitted for species of economical use." He remarks on the dodo, a bird whose disappearance in recent history was well chronicled, and he has low expectations for the survival of others: "The kangaroo and the emu are retreating rapidly before the progress of colonization in Australia; and it scarcely admits of doubt, that the general cultivation of that country must lead to the extirpation of both."[196]

To Cuvier, in contrast, extinction was the result of catastrophic events and involved many species at once. For Lyell, the extinction of old species and the creation of new species is an ongoing and overlapping process, similar to a population of individuals: People die and are born, but not all at once.

---

[191] Lyell, *Principles of Geology*, Vol. II, pp. 11, 60.
[192] Ibid, p. 56.
[193] Ibid, pp. 64, 65.
[194] Ibid, p. 94.
[195] Ibid, p. 124
[196] Ibid, pp. 141, 147–148 150.

To the early readers of *Principles of Geology*, Lyell's opposition to Lamarck might have seemed well grounded in science and reason. But it was more emotional than that. As he confessed some thirty years later, Lyell turned against Lamarck because of the materialist implication that man might have come from the apes. He was not, he admitted, ready to "go the whole orang."[197] The prospect of a simian ancestry of man would be a stumbling block for many.

Lyell thought he had been well served by William Whewell's review of the first volume of *Principles of Geology*, so he asked Whewell to review the second volume.[198] This appeared in *The Quarterly Review*.[199] With Lyell's rejection of Lamarck, Whewell wholeheartedly agrees, but he puts a natural theological spin on the creation of new species:

> The wisdom with which other organic forms have been fitted for their places in former states of the earth, resembles the wisdom with which the creatures about us are fitted for the earth as it is; but the power by which these varied forms were successively brought into being, resembles nothing of which we can see any vestige in the present world … our sagacity is altogether baffled, when we try to ascend to the act which has breathed the breath of life into generation after generation: and we find that even if our philosophy is allowed to burst the barriers of time, and to summon to its aid the energies of the elemental world, it is still unable to touch even the skirts of the garment of creative power which envelops the Supreme Being.[200]

But Whewell's review became best known for the two words he invented to describe the difference between the geologists like Lyell who believed that existing causes were sufficient to explain all the geological phenomena or the world, and those (like Cuvier and Buckland, with whom Whewell generally agreed) that past "epochs of paroxysmal and catastrophic action" were necessary:

> These two opinions will probably for some time divide the geological world into two sects, which may perhaps be designated as the *Uniformitarians* and the *Catastrophists*. The latter has undoubtedly been of late the prevalent doctrine, and we conceive that Mr. Lyell will find it a harder task than he appears to contemplate to overturn this established belief.[201]

At least in Britain, both "sects" were mostly united in their opposition to the transmutation of species, but they differed in how they interpreted the fossil record: For catastrophists, the mass extinctions of old species and the concurrent creation of new species were associated with catastrophic events that resulted in a progressive sequence of fossils from fish to

---

[197] *Life, Letters and Journals of Sir Charles Lyell*, ed. Katherine Murray Lyell, Vol. II (London: John Murray, 1881), https://babel.hathitrust.org/cgi/pt?id=hvd.32044029902822, p. 365.
[198] Wilson, *Charles Lyell: The Years to 1841*, p. 327.
[199] [William Whewell], Review of *Principles of Geology*, Vol. II, *The Quarterly Review*, Vol. XLVII, No. XCIII (Mar., 1832), https://books.google.com/books?id=hJpKAAAAcAAJ, pp. 103–132.
[200] Ibid, pp. 125–126.
[201] Ibid, p. 126.

amphibians, reptiles, and up to mammals. For uniformitarians, the lifespans of species between creation and extinction overlapped, and no progress occurred.

Transmutationists, however, combined a uniformitarian approach to geology with a belief in organic progress. They required an environment that changed slowly enough to allow species to adapt to it by altering their habits and hence their physiologies, but each new species represented an advance in complexity and organization over the species from which it arose.

Without transmutation, the origin of new species would remain an enigma. Several years later, in a three-volume history of science, William Whewell would cite this as a matter "of great interest, but also of great difficulty … A subject shrouded in mystery, and not to be approached without reverence…. In what manner do species which were not, begin to be?"[202]

> Are these new species created by the production, at long intervals, of an offspring different in species from the parents? Or are the species so created produced without parents? Are they gradually evolved from some embryo substance? Or do they suddenly start from the ground as in the creation of the poet?[203]

At which point Whewell quotes from Book VII of Milton's *Paradise Lost*:

> Perfect forms,
> Limbed and full-grown: out of the ground up rose,
> As from his lair, the wild beast where he wons
> In forest wild, in thicket, brake, or den; …
> The grassy clods now calved; now half-appeared
> The tawny lion, pawing to get free
> His hinder parts; then springs as broke from bonds,
> And rampant shakes his brinded mane; …

The poetic imagery is wonderful, but in the 1830s, no natural historian would dare to claim that new species emerge by clawing themselves out of the earth.

After Charles Lyell had used the first two volume of *Principles of Geology* to explore changes in the inorganic and organic world during the relatively brief timeframe of recorded history, the third volume,[204] published in 1833, delved into the distant past. To differentiate geological epochs, Lyell retains the terminology of Primary (for stratified and unstratified rocks in which no fossils are found), Secondary (formations with fossils of largely extinct species), and Tertiary (strata in which more modern types of species such as mammals are found), but he finds that reptiles and mammals provide little help in differentiating these periods:

---

[202] William Whewell, *History of the Inductive Sciences*, Book III (London: John W. Parker, 1837), https://books.google.com/books?id=RVgEAAAAQAAJ, p. 572.
[203] Ibid, p. 589.
[204] Charles Lyell, *Principles of Geology*, Vol. III (London: John Murray, 1833), https://babel.hathitrust.org/cgi/pt?id=nyp.33433066370366.

> Although the bones of mammalia in the tertiary strata, and those of reptiles in the secondary, afford us instruction of the most interesting kind, yet the species are too few, and confined to too small a number of localities, to be of great importance in characterizing the minor subdivisions of geological formations.[205]

Nor are fish or plants of much use, which leaves Lyell with testacea — otherwise known as seashells. Seashells are so important to Volume III that sixty pages of appendices are included that consolidate information about shells collected by French geologist Gérard Paul Deshayes.

Lyell wished to refine and subdivide the tertiary period, and he corresponded with William Whewell to derive names that were both succinct and etymologically correct.[206] Going backwards in time from the present, the names of the periods introduced by Lyell were the Pliocene (which he further divided into Newer Pliocene and Older Pliocene), Miocene, and the Eocene.[207] These terms are still in use: The Pliocene epoch is currently dated as about 2.6 to 5.3 million years ago, and the Miocene epoch — most notable from our perspective as the epoch in which apes diversified — is 5.3 to 23 million years ago. The Pliocene and Miocene epochs constitute the Neogene period. The Eocene epoch is now considered to be the middle epoch within the Paleogene period, and is currently dated as 34 to 56 million years ago.

Lyell differentiates these newly named epochs by the approximate mix of living and extinct species as determined by fossil shells: "we may say that about a thirtieth part of the Eocene shells are of recent species, about one-fifth of the Miocene, more than a third, and often more than half, of the older Pliocene, and nine-tenths of the new Pliocene."[208]

However, Lyell warns that the demarcations of the tertiary epochs are *not* based on "extraordinary revolutions of the surface of the globe." He anticipates that other periods will need to be introduced in the future, and that these are really "artificial divisions" resulting from "the present imperfect state of our information, and partly from the irregular manner in which geological memorials are preserved."[209] This is a direct result of Lyell's assumption of uniformity.

Much of Volume III involves explorations of different regions in Europe (primarily the British Isles, France, Italy, and Sicily), where geological formations expose strata of these periods. About halfway through the volume, Lyell includes a four-page section entitled "Supposed Effects of the Flood" in which he asserts that a universal flood is "a preternatural event far beyond the reach of philosophical enquiry," but if such a thing occurred, there is no evidence for it. He contends that "the earth's surface underwent no

---

[205] Ibid, p. 47.
[206] Wilson, *Charles Lyell: The Years to 1841*, pp. 305–307.
[207] These terms are introduced in Lyell, *Principles of Geology*, Vol. III, pp. 52–55.
[208] Ibid, p. 59.
[209] Ibid, pp. 56, 57, 56–57.

great modification at the era of the Mosaic deluge," and that we should not expect to find "any geological monuments of the catastrophe."[210]

Although Lyell sometimes discusses the reptiles and mammals found in the strata of the various epochs he describes, he does not perceive any chronological progression in the complexity of these animals. He doesn't even believe that the primary strata and rocks precede the existence of living things on earth. He proposes alternative names for the primary epoch because "the formations so designated sometimes belong to different epochs, and are not, in every case, more ancient than the secondary strata."[211]

In the concluding pages, Lyell denies that he has proposed an earth that "operated with absolute uniformity from all eternity," as someone in the *Quarterly Review* had accused him. The earth must have had a beginning despite "the monuments of events which may have happened millions of ages before our times." That beginning, however, might never be detected: "it cannot warrant us in presuming we shall be permitted to behold the signs of the earth's origin, or the evidences of the first introduction into it of organic beings." The last few paragraphs make a concession to the conventions of natural theology when Lyell writes that "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."[212]

Like the world that it describes, Lyell's *Principles of Geology* did not have an immediate cataclysmic effect on the reading public. That would take time. Twelve editions of the book would appear over the next 45 years as Lyell revised his descriptions and theory based on new discoveries and interpretations. An alternative single-volume *Elements of Geology* appeared in 1838, and a Student's edition in 1871. Only in retrospect did *Principles of Geology* become one of the most significant books on science published during the century. It had a profound cumulative effect, and the calm persuasive dignity of Lyell's writing did much to wean the Victorian mind off biblical chronology.

One of the most important of Lyell's early readers was the young Charles Darwin as he sailed to distant shores on the HMS *Beagle*. Darwin later wrote "I have always thought that the great merit of the *Principles* was that it altered the whole tone of one's mind, and therefore that, when seeing a thing never seen by Lyell, one yet saw it partially through his eyes."[213] Those eyes saw deep time.

The 1830s were a politically turbulent time in Britain. The early years were dominated by a debate over electoral reform. How districts were represented in Parliament was largely based on traditions going back to medieval times, with rare changes since. The city of Manchester had been disenfranchised in 1660, and despite its population boom during the industrial revolution — increasing from 95,000 to 310,000 residents just between 1811 and 1831 — it continued to have no representation in Parliament.

---

[210] Ibid, pp. 270, 273, 174.
[211] Ibid, p. 352.
[212] Ibid, pp. 383, 384.
[213] Quoted in Browne, *Charles Darwin: Voyaging*, p. 189.

Meanwhile, "rotten boroughs" had lost population but continued to be represented in the House of Commons. The most notorious of these was Old Sarum, in which an uninhabited "lump of stone and a green field" six miles from Stonehenge managed to send two members to Parliament.[214]

In 1832, Parliament passed the First Reform Act devoted to redistributing Parliamentary seats based on population (Manchester was awarded two seats) and extending the franchise to adult males owning properties worth at least £10. This increased the number of voters by about 50%, so that about 18% of adult males in England and Scotland could now vote.[215]

Charles Lyell and his father disagreed on reform: Lyell's father was a large landowner of Tory principles who opposed reform, but Lyell himself had more liberal tendencies. In 1831 the son voted for the Whig candidate, despite his feeling that the Tory candidate "is so gentlemanlike a man & so natural a character … that I wish with all my heart I could vote for him."[216]

Although *Principles of Geology* was ultimately quite influential, it wasn't even the most popular science book published in the 1830s. More major than Lyell's was a publishing event triggered by the 1829 death of a wealthy eccentric and his equally eccentric will.

The eccentric was the Reverend Francis Egerton, the eighth Earl of Bridgewater, and with his death, the last. His father, a bishop, was first cousin to the third Duke of Bridgewater, known as the "canal Duke" for his championship of canals and his commission of the pioneering Bridgewater Canal.[217] The money from that flowed throughout the family.

Francis Egerton spent much of his time immersed in classical literature while pursuing other interests, one of which resulted in at least five illegitimate children.[218] From 1802, he lived in Paris but continued to draw an income as an absentee rector from his two parishes in England. Egerton also raised dogs, and the 1875 book *English Eccentrics and Eccentricities* describes his habit of dining with at least "a dozen of his favourite dogs: seated at the table, each properly outfitted with a napkin tied around the neck." Although Egerton gets only a page and a half biography in that book, the frontispiece is a full-color artist's rendition of a typical Egerton dinner.[219]

---

[214] Antonia Fraser, *Perilous Question: Reform or Revolution? Britain on the Brink, 1832* (NY: Public Affairs, 2013), pp. 18–19.
[215] Ibid, p. 269.
[216] Wilson, *Charles Lyell: The Years to 1941*, p. 321–2.
[217] A rather sensational family biography is Bernard Falk, *The Bridgewater Millions: A Candid Family History* (London: Hutchinson & Co., 1942).
[218] Jonathan Richard Topham, *'An Infinite Variety of Argument': The Bridgewater Treatises and British Natural Theology in the 1830s*, thesis submitted to the University of Lancaster for the degree of Doctor of Philosophy, February 1993, p. 26.
[219] John Timbs, *English Eccentrics and Eccentricities*, London: Chatto and Windus, 1875, https://books.google.com/books?id=Aqo0AAAAMAAJ, p. 103–104 and frontispiece (which appears just before the title page).

On his death in 1729, Egerton's will left a collection of historical manuscripts to the British Museum, which formed one of the museum's foundation collections.[220] Also bequeathed was the sum of £8,000 to be paid to a person or persons selected by the President of the Royal Society

> to write, print, publish, and expose to public sale, one thousand copies of a work "On the Power, Wisdom, and Goodness of God as manifested in the Creation," illustrating such work by all reasonable arguments; as for instance, the variety and formation of God's creatures, in the animal, vegetable, and mineral kingdoms; the effect of digestion, and thereby of conversion; the construction of the hand of man, and an infinite variety of arguments…[221]

The Earl of Bridgewater was effectively commissioning a new book on natural theology at a time when William Paley's book was still considered the definitive statement.

Nobody had ever heard of anyone being paid the exorbitant sum of £8,000 to write a book, so the money was divided among eight authors getting £1000 each. These books became known by the words printed inside each volume that quoted from Egerton's will:

The Bridgewater Treatises
On the Power Wisdom and Goodness of God
As Manifested in the Creation

The Bridgewater Treatises promised up-to-date state-of-the-art theologically interpreted science, and they delivered. As the eight books appeared between 1833 and 1836 — many of them in multiple volumes — they totaled over 6,000 pages and became the most extensive presentation of natural theology ever published. Like a mini-encyclopedia, the books formed a row of attractive volumes that defined mid-1830s science as well as orthodoxy.

First out of the gate was the Rev. William Whewell in 1833, who took on the topic of *Astronomy and General Physics Considered with Reference to Natural Theology*. Whewell begins by demonstrating how the earth and its inhabitants of animals and plants have been created in a state of mutual adaptation, a situation "found to convey the conviction of a wise and benevolent design, which has been exercised in producing such an arrangement between the internal constitution and the external circumstances of organized beings." This is the result of "a Creator, who, in producing one part of his work, was not forgetful or careless of another." [222]

For example, the length of the year, which is determined by fixed laws governing the revolution of the earth around the sun, is ideally suited for the rhythms of the vegetation that grows on the earth. "These two periods are *adjusted* to each other."[223] Similarly, the

---

[220] Ibid, p. 38.
[221] "Obituary — Earl of Bridgewater," *The Gentleman's Magazine, and Historical Chronicle*, Vol. XCIX (June, 1829), https://books.google.com/books?id=hcxDAQAAMAAJ, p. 560.
[222] William Whewell, *Astronomy and General Physics Considered with Reference to Natural Theology*, London: Pickering, 1833, https://books.google.com/books?id=1FgOAAAAQAAJ, pp. 19, 20.
[223] Ibid, p. 28.

length of the day has been set to agree with the human and animal cycles of sleep and wakefulness. The size and mass of the earth is such that its gravitational attraction is ideal for the vegetation that takes root below the ground and the animals that walk its surface. The oceans are the proper size to provide just the right amount of moisture, the atmosphere gives us the air we breathe, and the various climates around the world serve to sustain life in many different forms. "We conceive that this variety and succession of fitness for cultivation, shows undoubted marks of a most foreseeing and benevolent design in the Creator of man and of the world."[224] Whewell asks,

> is it by chance that the air and the ear exist together? Did the air produce the organization of the ear? or the ear, independently organized, anticipate the constitution of the atmosphere? Or is not the only intelligible account of the matter, this, that one was made for the other: that there is a mutual adaptation produced by an Intelligence which was acquainted with the properties of both; which adjusted them to each other as we find them adjusted, in order that birds might communicate by song, that men might speak and hear, and that language might play its extraordinary part in its operation upon men's thoughts, actions, institutions, and fortunes?[225]

Whewell remarks that it is a commonplace observation of natural theology that the "human eye exhibits such evidence of design and skill in its construction, that no one, who considers it attentively, can resist this impression." Yet, Whewell's subject in this book is astronomy and physics, so he turns the equation around: "As the eye is made for light, so light must have been made, at least among other ends, for the eye."[226]

Towards the end of his book, Whewell reduces natural theology to its essence. "To most people it appears that the mere existence of a law connecting and governing any class of phenomena, implies a presiding intelligence which has preconceived and established that law."[227] But Whewell then goes further in asserting that the human mind itself has been designed for worship:

> The religious feeling, the conviction of a supernatural power, of an intelligence connecting and directing the phenomena of the world, had not its *origin* in the worship of sun, or stars, or elements; but was itself the necessary though unexpressed foundation of all worship, and all forms of false, as well as true, religion. The contemplation of the earth and heavens called into action this religious tendency in man; and to say that the worship of the material world formed or suggested this religious feeling, is to invert the order of possible things in the most unphilosophical manner.[228]

---

[224] Ibid, p. 69.
[225] Ibid, pp. 123–4.
[226] Ibid, p. 128.
[227] Ibid, pp. 295–296.
[228] Ibid, pp. 297–298.

The study of the nature doesn't lead us to believe in God as natural theology had historically suggested. Instead, our innate belief in God has directed us to the study of the natural world.

Whewell was a talented wordsmith. In his review of Lyell's *Principles of Geology*, he came up with Uniformitarians and Catastrophists to describe the two "sects" of geology. A couple years later, in an 1834 review of Mary Somerville's *On the Connexion of the Physical Sciences*, he introduced the word "scientist" into the English language to replace the clumsy (and gender-specific) "man of science."

Smack in the middle of his Bridgewater Treatise, William Whewell introduces a catchy name for Laplace's theory of the formation of the solar system. This term will become a permanent part of scientific vocabulary. He calls it the *nebular hypothesis*. In later editions of *Exposition du Système du Monde*, Laplace had integrated Herschel's work on nebulas into his theory, and he had come to describe the solar system as the condensation of a swirling nebular.[229] Now "The Nebular Hypothesis" is the title of a ten-page chapter in Whewell's Bridgewater Treatise.

Because this is a work of natural theology, the last thing Whewell wants to imply is that the nebular hypothesis removes God from the creation of the solar system. Whewell poses a few questions, beginning with "how came the sun and its atmosphere to have such materials, such motions, such a constitution, that these consequences follow from their primordial condition?"[230] and then continues with 32 similar questions. Whewell does not deny that the solar system could result from the conditions that Laplace described, but he maintains a safely skeptical position by presenting these questions to which the implied answer must to be "God." The last question he asks is "how matter came to be thus luminous?" and then finishes the chapter with the only quotation of scripture in the entire book:

> If we establish by physical proofs, that the first fact which can be traced in the history of the world, is that "there was light;" we shall still be led, even by our natural reason, to suppose that before this could occur, "God said, let there be light."[231]

Giving names to things allows them to be more easily discussed, and by introducing the term *nebular hypothesis*, William Whewell instantly elevated the theory's status as a topic for further discussion and promotion.

---

[229] See the English translation of the 5th edition of Laplace's *Exposition du Système du Monde* (1824): M. Le Marquis de Laplace, *The System of the World*, trans. Rev. Henry H. Harte (Dublin University Press, 1830), Vol. II, https://books.google.com/books?id=KFM5AQAAMAAJ, pp. 324–342, with Laplace's notes describing the process in more detail, pp. 354–369, and the translator's notes, pp. 538–539.

[230] William Whewell, *Astronomy and General Physics*, p. 184.

[231] Ibid, p. 191.

The other historically significant Bridgewater Treatise is William Buckland's *Geology and Mineralogy Considered with Reference to Natural Theology* of 1836.[232] It is Buckland's only book other than *Reliquiæ Diluvianæ*, and therefore might be considered his definitive statement on the subject. A surprise awaits within its pages.

In an early chapter on the "Consistency of Geological Discoveries with Sacred History," Buckland acknowledges the existence of "the lapse of very long periods of time, before the creation of man" during which the globe has "advanced through a series of creative operations, succeeding one another at long and definite intervals of time." The Bible's description of the Creation is not supposed to be historical but "intended only to be used as a guide of religious belief and moral conduct." [233]

Buckland does not equivocate about this age of the earth. Ascribing "the formation of all the stratified rocks to the effects of the Mosaic Deluge," he says, "is irreconcileable with the enormous thickness and almost infinite subdivisions of those strata, and with the numerous and regular successions which they contain of the remains of animals and vegetables…" Genesis does not specify a particular timeframe. Indeed, "millions and millions of years may have occupied the indefinite interval, between the beginning in which God created the heaven and the earth, and the evening or commencement of the first day of the Mosaic narrative." The sun and moon were not created on the fourth day. They were instead "created at the indefinitely distant time" [234] and hidden from view until the fourth day.

Whewell's Bridgewater Treatise had been published three years before Buckland's, so Buckland is able to refer in a footnote to "the nebular hypothesis." He calls it

> the most simple, and therefore the most probable theory, respecting the first condition of the material elements that compose our solar system. Mr. Whewell has shown how far this theory, supposing it to be established, would tend to exalt our conviction of the prior existence of some presiding Intelligence.[235]

This is perhaps a much stronger endorsement than Whewell anticipated.

The "absence of organic remains in the primary strata" indicates that a long period elapsed "antecedent to the beginning of animal or vegetable life." However, based on arguments presented by Lyell in the second volume of *Principles of Geology*, Buckland denies a process of transmutation of species, or as he phrases it, "the formation of more recent from more ancient species, by successive developments, without the interposition of direction and repeated acts of creation."[236]

---

[232] William Buckland, *Geology and Mineralogy Considered with Reference to Natural Theology*, London: William Pickering, 1836, Volume I: https://books.google.com/books?id=HihEAQAAMAAJ, Volume II (engravings): https://books.google.com/books?id=TjQTAAAAQAAJ.
[233] Buckland, *Geology and Mineralogy*, vol I, pp. 8, 11, 15.
[234] Ibid, pp. 16, 21–22, 29.
[235] Ibid, p. 40 footnote.
[236] Ibid, pp. 53, 54.

Much of the remainder of Buckland's *Geology and Mineralogy* discusses not rocks but fossils. He shows in each case how extinct animals were adapted to their particular environments, offering a proof of design. Again referencing Lyell, Buckland notes "the important fact of the total absence of any vestiges of the human species throughout the entire series of geological formation." The conclusion must be "that these animals lived and died before the creation of man."[237]

In a section entitled "Fossil Saurians," Buckland discusses the order of reptiles that geologists call Sauria, which was often used during this time to describe particularly large extinct lizards. (A few years later, in 1841, Richard Owen would combine coin the word *dinosaur*, meaning "terrible lizard," as a suborder of the Sauria.) Buckland conjures what is now a familiar image of this ancient age,

> a time when reptiles not only constituted the chief tenants, and most powerful possessors of the earth, but extended their dominion also over the waters of the seas; and that the annals of their history may be traced back through thousands of years, antecedent to that latest point in the progressive stages of animal creation, when the first parents of the human race were called into existence.[238]

A later section discusses "the flying reptiles, which have been ranged by Cuvier under the genus Pterodactyle; a genus presenting more singular combinations of form, than we find in any other creatures yet discovered amid the ruins of the ancient earth."[239]

Throughout the many ages of Creation, Buckland finds similarities among the extinct animals, and even ourselves:

> Pursuing the analogies of construction, that connect the existing inhabitants of the earth with those extinct genera and species which preceded the creation of our race, we find an *unbroken chain of affinities* [italics added] pervading the entire series of organized beings, and connecting all past and present forms of animal existence by close and harmonious ties. Even our own bodies, and some of their most important organs, are brought into close and direct comparison with those of reptiles, which, at first sight, appear the most monstrous productions of creation; and in the very hand and fingers with which we write their history, we recognize the type of paddles of the Ichthyosaurus and Plesiosaurus.[240]

Yet to Buckland, these similarities among extinct and living species demonstrate not transmutation of species but "the same eternal principle of Wisdom and Intelligence, presiding from first to last over the total fabric of Creation."[241]

In a chapter towards the end of his treatise entitled "Proofs of Design in the Dispositions of Strata of the Carboniferous Order," Buckland again addresses the reason for the long existence of the earth prior to the emergence of humans, and attributes it to the

---

[237] Ibid, p. 103.
[238] Ibid, p. 167.
[239] Ibid, p. 221.
[240] Ibid, p. 213.
[241] Ibid, p. 186.

necessary foundation for England's role in the industrial revolution. He praises "our grand supplies of fossil fuel" and the "inestimable treasures of mineral Coal." He describes England's coal fields, and the "15,000 steam engines … daily at work."[242]

> We need no further evidence to shew that the presence of coal is, in an especial degree, the foundations of increasing population, riches, and power, and of improvement in almost every Art which administers to the necessities and comforts of Mankind. And, however remote may have been the periods, at which these materials of future beneficial dispensations were laid up in store, we may fairly assume, that, besides the immediate purposes effected at, or before the time of their deposition in the strata of the Earth, an ulterior prospective view to the future uses of Man, formed part of the design, with which they were, ages ago, disposed in a manner so admirably adapted to the benefit of the Human Race.[243]

Buckland doesn't need to make explicit that the providential nature of England's coal and its role in the industrial revolution suggest that the English are truly God's chosen people.

In one of the most astounding recantations in the history of science, Buckland's Bridgewater Treatise ignores the Deluge almost entirely, relegating the most extensive discussion to a footnote! He characterizes the event previously described in *Reliquiæ Diluvianæ* as "a violent inundation, which overwhelmed great part of the northern hemisphere" and resulted in the extinction of large number of species. But this was not the Biblical flood. It was instead "the last of many geological revolutions that have been produced by violent irruptions of water, rather than the comparatively tranquil inundation described in the Inspired Narrative."[244]

Several years later, Louis Agassiz would convince Buckland that what had been previously interpreted as evidence for the Deluge was instead the result of glaciation. Around 1840, Buckland spent some time revising *Reliquiæ Diluvianæ*, changing references from the Noachian flood to "inundation." If this revision had been completed and published, the new title would have been *Reliquiæ Diluviales et Glaciales* — Relics of Floods (plural) and Glaciers.[245]

Several of the other Bridgewater Treatise authors found it necessary to argue against transmutation of species. John Kidd, a professor of medicine at Oxford, wrote *On the Adaptation of External Nature to the Physical Condition of Man* (1833) and cited Cuvier to argue against transmutation because "in every animal the several parts have such a mutual relation, both in form and function, that if any part were to undergo an alteration, in even a slight degree, it would be rendered incompatible with the rest." There might be some variation "but the variation never proceeds beyond certain limits." This is

---

[242] Ibid, pp. 524–5, 534.
[243] Ibid, pp. 537–8.
[244] Ibid, pp. 94–95 footnote.
[245] Rupke, *The Great Chain of History*, p. 106. For an image of Buckland's changes to the text, see Dennis R. Dean, *The Rise and Fall of the Deluge* (*Journal of Geological Education*, Vol. 33, No. 2, March 1985), pp. 84–93, p. 90.

demonstrated by the mummies of Egypt: "the general form, and size, and proportions were the same three thousand years since, that they are at present."[246]

One of the criticisms of the Bridgewater Treatises focused on their disparate vantage points. There was no attempt to coordinate a uniform message. Each treatise reflected its individual author, and these authors often had strong opinions. The oldest and most conservative of the authors was the Rev. William Kirby, an entomologist and rector of Barham. He begins his Introduction to *On the Power, Wisdom, and Goodness of God as Manifested in the Creation of Animals and in their History, Habits, and Instincts* with a traditional statement of the relationship between natural theology and revelation:

> The *Works* of God and the *Word* of God may be called the two doors which open into the temple of Truth; and as both proceed from the same Almighty and Omniscient Author, they cannot, if rightly interpreted, contradict each other…[247]

What soon becomes obvious is that Kirby favors the Word over any wayward interpretation of the Works. Four pages in, he launches an assault on Laplace and Lamarck, "both of whom, from their disregard of the word of God, and from seeking too exclusively their own glory, have fallen into errors of no small magnitude"[248]

Kirby mocks Laplace's hypothesis of the origins of the Solar System, "in which we find that this primitive cause, instead of the Deity, is a nebulosity originally so diffuse that its existence can with difficulty be conceived." But this is nothing compared to his 20-page assault of Lamarck. "Lamarck's great error, and that of many others of his compatriots, is materialism; he seems to have no faith in any thing but *body*, attributing every thing to a physical, and scarcely any thing to a metaphysical cause."[249]

Rather than imitating Buckland and reconsidering the Noachian Flood in light of recent geological research, Kirby remains a true believer:

> He who willed the deluge, and the destruction of the primeval earth and heavens by it, kept in his own hands the reins, and guided the whole body by means that he employed to fulfil the great purposes of his Providence, saying to every agent, "*Thus far shalt thou go, and no further*."[250]

Kirby includes a 13-page Note[251] in the Appendix that confesses that his "knowledge of Geology and its principles" is slight, but since our knowledge of the globe that we inhabit is "very *superficial*; that it is only, as it were, *skin* deep," then we need to rely on "the *highest*

---

[246] John Kidd, *On the Adaptation of External Nature to the Physical Condition of Man*, London: William Pickering, 1833, https://books.google.com/books?id=ZksVAAAAYAAJ, pp. 328–330.
[247] William Kirby, *On the Power, Wisdom, and Goodness of God as Manifested in the Creation of Animals and in Their History, Habits, and Instincts*, London: Pickering, 1835, Volume I, https://books.google.com/books?id=UVoOAAAAQAAJ, pp. xvii.
[248] Ibid, p. xx.
[249] Ibid, p. xxvii.
[250] Kirby, *On the Power, Wisdom, and Goodness of God*, p. 27.
[251] Kirby, *On the Power, Wisdom, and Goodness of God*, pp. 376–389.

authority" for the true nature of the Deluge, whose cause was "the universal corruption of the human race."

Kirby is also skeptical that "the Saurians were the mighty masters, as well as monsters, of the primeval animal kingdom and the lords of the creation before the existence of the human race." This hypothesis "cannot be reconciled with the account of the creation of animals as given in the first chapter of Genesis."[252] Kirby discusses how the bones of these reptiles could have been scattered during the Deluge so that they only seem to originate in ancient times. Or, the Saurians could be the dragons referred in to Psalm 44:19, which "may not improbably be still in existence in the subterranean ocean."[253]

> But, setting aside these arguments upon the uncertain facts on which this hypothesis is built, if we turn our attention to the reason of the thing, who can think that a Being of unbounded power, wisdom, and goodness should create a world merely for the habitation of a race of monsters, without a single rational being in it to glorify and serve him. The supposition that these animals were a separate creation, independent of man, and occupying his eminent station and throne upon our globe long before he was brought into existence, interrupts the harmony between the different members of the animal kingdom, and dislocates the beautiful and entire system, recorded with so much sublimity and majestic brevity in the first chapter of Genesis.[254]

William Kirby is an exception to the consensus that had developed among most men of science in their acceptance of an ancient earth.

One reader of William Whewell's Bridgewater Treatise was startled to encounter the following passage that directly insulted his vocation:

> We may thus, with the greatest propriety, deny to the mechanical philosophers and mathematicians of recent times any authority with regard to their views of the administration of the universe; we have no reason whatever to expect that their speculations any help, when we attempt to ascend to the first cause and supreme ruler of the universe.[255]

Mathematician Charles Babbage felt sure he had something to contribute to natural theology, and under the assumption that eight is *not* enough, he hastily wrote an unsolicited and unreimbursed *Ninth Bridgewater Treatise*, published in 1837,[256] quickly followed by an expanded second edition in 1838.[257]

---

[252] Ibid, p. 36.
[253] Ibid, p. 33.
[254] Ibid, p. 39.
[255] Whewell, *Astronomy and General Physics*, pg. 334.
[256] Charles Babbage, *The Ninth Bridgewater Treatise. A Fragment* (London: John Murray, 1837), https://books.google.com/books?id=gB4HAAAAQAAJ.
[257] Charles Babbage, *The Ninth Bridgewater Treatise. A Fragment* (London: John Murray, 1838), https://books.google.com/books?id=Oi3IhTZyVCAC. It is this 2nd edition that is most often cited and

Babbage's work is short, disorganized, and scattershot, consisting of a hodgepodge of topics sometimes interrupted with blank sections that were either intended for later elaborations or to mark material that was removed at the request of two people who read the manuscript, Charles Lyell and Adam Sedgwick.

The frustratingly incomplete nature of the *Ninth Bridgewater Treatise* is much in keeping with other aspects of Babbage's life: As the inventor of a machine he called the Analytical Engine, Charles Babbage is today credited as being the designer of the first programmable digital computer but not (alas) its builder. As Babbage continued to redesign and refine his Analytical Engine, he was never able to complete a working machine. A London weekly once referred to him as "the logarithmetical Frankenstein,"[258] equating his calculating machine with the patchwork monster in Mary Shelley's 1818 novel.

Babbage's *Ninth Bridgewater Treatise* contains short chapters on providence, future punishments, and free will, as well as sections on geology. Babbage is adamant that all empirical evidence indicates "that the earth has existed for an enormous period, extended, perhaps, over millions of years" in contrast to "the history of the Creation as delivered by Moses, that the earth was first created about six thousand years ago." Like others, Babbage asserts that the Genesis timeframe applies solely to the human race:

> A different interpretation has been lately put upon that passage of the sacred writings; and, according to the highest authorities of the present time, it was not the intention of the writer of the book of Genesis to assign this date to the creation of our globe, but only to that of its most favored inhabitants. [259]

Otherwise, "it is now admitted by all competent persons, that the formation even of those strata which are nearest the surface must have occupied vast periods — probably millions of years — in arriving at their present states."[260]

Babbage's treatise contains two other unusual sections. One is a mathematical refutation of David Hume's famous argument against miracles. Babbage quotes Hume's summary of his argument as "no testimony is sufficient to establish a miracle, unless the testimony be of such a kind, that its falsehood would be more miraculous than the fact which it endeavors to establish."[261] In a 12-page appendix,[262] Babbage expresses this

---

which is included as Volume 9 in *The Works of Charles Babbage* (NYU Press, 1989). This is the edition cited here.

[258] *The London Literary Gazette; and Journal of Belles Lettres, Arts, Sciences, &c.*, No. 808 (Saturday, July 14, 1832), https://books.google.com/books?id=OJBFAQAAMAAJ, p. 442.

[259] Ibid, pp. 63–64.

[260] Ibid, pp. 79–80.

[261] Ibid, p. 122, from David Hume, *Philosophical Essays Concerning Human Understanding* (London: A. Millar, 1748), https://books.google.com/books?id=LB4VAAAAQAAJ, p. 182; later known as *An Enquiry Concerning Human Understanding*, Ch. X, paragraph 13.

[262] Ibid, pp. 192–203.

statement mathematically using probability theory to judge the likelihood that a group of people might offer sufficient testimony concerning a resurrection from the dead.[263]

The other interesting section of Babbage's treatise is based on his calculating engine.[264] He describes a possible configuration of the engine to display the sequence of natural numbers: 1, 2, 3, 4, 5, and so forth. After observing the progression of this sequence, our assumption is that the machine is following something akin to a natural law that will continue indefinitely. But after many hours, when the machine reaches 100,000,001, it suddenly jumps to 100,010,002, and thereafter makes leaps of 20,001, 30,001, and so forth.

What has happened? Based on the first hundred million numbers, a natural law had been empirically established by us human observers, but now a violation of that law seems to have occurred — in other words, a miracle. It is hardly a miracle, however. The configuration of the machine was just a little more complex than we originally assumed based on the first hundred million numbers. Babbage has blurred the distinction between physical law and miracle, and redefined a miracle as a layer of undiscovered complexity to natural law.

In the few pages of his discussion, Babbage has implicitly suggested that the old Clockwork Universe paradigm of the Newtonians might be replaced with a much more sophisticated paradigm of the Computational Universe — a concept that wouldn't be explored more fully until the 1990s and later in the writings of physicists David Deutsch and Seth Lloyd. Babbage even notes that his machine might be configured so that even its creator wouldn't know when a change in the functioning of the machine would occur. He notes that this has implications for the existence of free will,[265] but to the more modern reader, the indeterminate nature of such a machine also seems to presage the work of Alan Turing a century later. Several years before digital computers and computer programs existed, Turing proved that there was no way to determine what a computer program might do without actually running the program or (equivalently) a simulation.[266]

Coming on the heels of the Bridgewater Treatises was an 1837 book that popularized the nebular hypothesis even more: The author was John Pringle Nichol, Professor of Practical Astronomy of the University of Glasgow, and while the book's title *Views of the Architecture of the Heavens* might not entirely suggest a romantic approach to the subject, the subtitle (*in a Series of Letters to a Lady*) was a clear indication that a gentle approach would be taken.[267]

---

[263] I hope to explore the philosophical background and nature of this argument and the next in more depth in a forthcoming book tentatively entitled *The Mathematics of Miracles: David Hume, Charles Babbage, and the Ninth Bridgewater Treatise*.

[264] Babbage, *Ninth Bridgewater Treatise*, 2nd edition, pp. 30–49.

[265] Ibid, pp. 167–71.

[266] Charles Petzold, *The Annotated Turing: A Guided Tour through Alan Turing's Historic Paper on Computability and the Turing Machine* (NJ: Wiley, 2008). For ideas about the "computational universe," see pp. 343ff.

[267] John Pringle Nichol, *Views of the Architecture of the Heavens, in a Series of Letters to a Lady* (Edinburgh: William Tait, 1837), https://books.google.com/books?id=sPleAAAAcAAJ.

Nichol relies greatly on the researches of "the two Herschels"[268] by which he means William Herschel and his son John, who had continued his father's astronomical work. But Nichol doesn't neglect to pay homage to William's

> devoted maiden Sister, who braved with him the inclemency of the weather — who heroically shared his privations that she might participate in his delights — whose pen, we are told, committed to paper his notes of observations as they issued from his lips…. she it was — MISS CAROLINE HERSCHEL — who helped our astronomer to gather an imperishable name.[269]

Nichol's ecstatic exposition of the nebular hypothesis doesn't come until nearly the end of his book, but his description of the theory of "the illustrious LAPLACE"[270] includes none of Whewell's doubts or qualifications:

> The Cosmogony has thus every mark of truth: its roots are *seen* in the Heavens, and it appears to go through every nook and alley of solar and planetary arrangements, not only explaining them but comprehending their variety and deducing the whole from one grand principle. How different the Cosmogony of BUFFON — a man to whom genius was never wanting … how different and fantastic his idea that planets were chips struck off the sun by the collision of comets! Not one of the fundamental conditions of our system's mechanism could be explained by this wild and reckless imagination, whereas Laplace's bold and brilliant induction (may I not now so name it?) includes and resolves all![271]

If the intellectual mainstream among English readers is represented by the *Encyclopædia Britannica*, then 1837 is also the year that an ancient earth became part of that foundation. The 7th edition of the *Encyclopædia Britannica* had a new article on geology (but appearing under the heading "Mineralogy"[272]) by John Phillips, who had married the sister of famed geologist William Smith, became professor of geology at King's College London, and would later coin the word *Mesozoic*. The entire text of the article was also published as a book, *A Treatise of Geology*, in 1837.[273]

In the penultimate chapter on Geological Time, Phillips amasses the evidence for long periods of geological formation, and concludes:

> And when we behold conglomerate rocks which hold fragments of other earlier deposits, and, in these fragments, the organic remains of still earlier periods which had already undergone their peculiar mineral changes; when we collect the history of such an organic form, — its existence in the sea, — its sepulture in

---

[268] Ibid, p. viii.
[269] Ibid, pp. 113–114.
[270] Ibid, p. 177.
[271] Ibid, pp. 178–179.
[272] John Phillips, "Mineralogy," *The Encyclopædia Britannica*, 7th edition, Vol. XV (Edinburgh: Adam and Charles Black, 1842), https://books.google.com/books?id=dPdMAQAAMAAJ, pp. 112–241.
[273] John Phillips, *A Treatise on Geology, Forming the Article under that Head in the Seventh Edition of the Encyclopædia Britannica* (Edinburgh: Adam and Charles Black, 1837), https://books.google.com/books?id=EgUAAAAAQAAJ.

> a vast oceanic deposit of limestone, or in a littoral aggregation of sandstone, — the induration of this rock, — its uplifting by subterranean forces, — the rolling of it to pebbles, — the reunion of them in a totally different kind of substance, — it is evident that no greater folly can be committed than to think to serve the cause of truth by contracting the long periods of geology into the compass of a few thousand years.[274]

It is with this acclamation of an ancient earth that the Victorian Era officially began on June 20, 1837, when King William IV died and his niece, the 18-year-old Princess Alexandrina Victoria, became queen.

In that transitional year of 1837, the poet Alfred Tennyson "was deeply immersed"[275] in Lyell's *Principles of Geology*. He had still been at Cambridge when Lyell's first volume was published in 1830, and his tutor there was William Whewell, so Tennyson might have known about the book since then.

For several years Tennyson had been poking away on a poem in memory of his friend from Cambridge, Arthur Hallam. The two had met in 1829, and based on their backgrounds and temperaments, were unlikely to become friends. Tennyson was moody and depressive, the product of a turbulent family life beset by congenital epilepsy, alcoholism, opium addiction, mental illness, verbal abuse, and domestic violence. Arthur Hallam had a much calmer and affluent background.

But friends they became, and when Arthur Hallam met Tennyson's 18-year-old sister Emily, a romance and an engagement ensued. In the summer of 1833, Arthur Hallam toured Europe with his father for the last time before his marriage to Emily. In Vienna, Arthur wasn't feeling well. He fell asleep in a chair and his father found him dead the next morning, apparently of apoplexy, or what would now be termed a stroke. Tennyson received a letter informing him of his friend's death, and then he had to tell his sister.

Very soon after Hallam's death, Tennyson began writing verses with an informal bouncy iambic tetrameter rhythm and a peculiar ABBA rhyming scheme that seemed to lend itself to confessions of uncertainty and inadequacy. For years he worked at it, frequently incorporating various influences that suggested different ways of understanding Hallam's death.[276] Volume II of *Principles of Geology* impressed upon Tennyson the savagery of nature. Despite our religious instruction that all life is precious to God, Nature seems not so benevolent.

> Are God and Nature then at strife,
> That Nature lends such evil dreams?

---

[274] Ibid, p. 293.
[275] Hallam Tennyson, *Alfred Lord Tennyson: A Memoir*, Vol. I (New York: Macmillan, 1898), p. 162.
[276] Much of this analysis is based on Eleanor Bustin Mattes, *In Memoriam: The Way of a Soul: A Study of Some Influences that Shaped Tennyson's Poem* (NY: Exposition Press, 1951).

So careful of the type she seems,
So careless of the single life;[277]

But even this supposition is wrong. Lyell's book described extinctions of entire species, and Tennyson quickly corrects his mistake:

'So careful of the type?' but no.
From scarped cliff and quarried stone
She cries 'a thousand types are gone:
I care for nothing, all shall go.

Thou makest thine appeal to me:
I bring to life, I bring to death:
The spirit does but mean the breath:
I know no more.' And he, shall he,

Man, her last work, who seem'd so fair,
Such splendid purpose in his eyes,
Who roll'd the psalm to wintry skies,
Who built him fanes of fruitless prayer,

Who trusted God was love indeed
And love Creation's final law —
Tho' Nature, red in tooth and claw
With ravine, shriek'd against his creed —

Who loved, who suffer'd countless ills,
Who battled for the True, the Just,
Be blown about the desert dust,
Or seal'd within the iron hills?

No more? A monster then, a dream,
A discord. Dragons of the prime,
That tare each other in their slime,
Were mellow music match'd with him.

O life as futile, then, as frail!
O for thy voice to soothe and bless!
What hope of answer, or redress?
Behind the veil, behind the veil.[278]

---

[277] Alfred Tennyson, *In Memoriam* (London: Edward Moxon, 1850), https://books.google.com/books?id=z1gJAAAAQAAJ, canto LIV, p. 78. Tennyson's changes made in later editions resulted in the cantos being numbered differently. All references here are to the first edition of 1850.
[278] Ibid, canto LV, pp. 80–81.

The "dragons of the prime" are likely references to giant extinct lizards at the time called Saurians but soon to be called Dinosaurs. The savage nature of these monsters (as they were visualized at the time) seems more in tune with the violence and ruthlessness of nature than man, who is nonetheless slated for extinction along with everything else. In the context of this vision, a hope of preferential treatment seems quaint and unrealistic. The existence of a soul that survives death is ridiculous if man himself is a miniscule blip on the vast sweep of natural history.

With another four quatrains, Tennyson bid his friend adieu and prepared to end the poem, but he could not leave with the bleak image of "Nature, red in tooth and claw" still vividly dripping on the page. Tennyson needed to find a more optimistic vision of the future. That inspiration came in one of the most popular and controversial books of the era.

Published anonymously in October 1844, *Vestiges of the Natural History of Creation* is an ambitious and dazzling tour de force that takes the reader from the origins of the universe to the future of the human race in 390 airy pages. When the author claims towards the end that "The book, as far as I am aware, is the first attempt to connect the natural sciences into a history of creation," [279] that's not bragging. No one had ever before constructed such a grandiose sweeping epic of how we got here and where we're going.

Vestiges — as the book soon came to be known — begins rapturously in the vastness of space. (The author later revealed that Nichol's *Views of the Architecture of the Heavens* was an inspiration.[280]) Stars, planets, and nebulas come into view, and Laplace's nebular hypothesis is buoyed with a recent mathematical analysis by French philosopher and originator of positivism, Auguste Comte. (Just the previous year, philosopher John Stuart Mill also cited Comte's mathematics in his book *A System of Logic* for a brief discussion of the "celebrated speculation of Laplace."[281])

The nebular hypothesis serves as both a springboard and a model for the remainder of the book. All the processes that *Vestiges* describes are the consequence of natural law, and all involve progressive development. Beyond the author's compelling narrative that synthesizes a host of eclectic and extensive research, *Vestiges* is also a polemic. The underlying perspective is a deist and materialist flavor of natural theology enlivened with a thrilling progressive thrust.

After the earth has been created, *Vestiges* presents the history of its life: sea plants, coral, crustacea, fish, and then land plants and animals beginning with reptiles and birds. It its exposition of the earth's geology and fossils, *Vestiges* relies on many of the usual

---

[279] [Robert Chambers], *Vestiges of the Natural History of Creation* (London: John Churchill, 1844), p. 388. An attractive reprint of the first edition was published by the University of Chicago Press in 1994.

[280] James A. Secord, *Victorian Sensation: The Extraordinary Publication, Reception, and Secret Authorship of Vestiges of the Natural History of Creation* (University of Chicago Press: 2000), pp. 90-91. This is the indispensable history of *Vestiges* and much, much more.

[281] John Stuart Mill, *A System of Logic, Ratiocinative and Inductive, Being a Connected View of the Principles of Evidence, and the Methods of Scientific Investigation*, Vol. II (London, John W. Parker, 1843), pp 27–29.

suspects: Lyell, Cuvier, Buckland, and even a "Mr. Darwin," who "has discovered, in the reptile-peopled Galapagos Islands, in the South Sea, a marine saurian from three to four feet long."[282] (The young naturalist had been there in 1835.)

In full agreement with the many authorities that the author of *Vestiges* has consulted, the book asserts that

> there is no authentic or satisfactory instance of human remains being found, except in deposits obviously of very modern date; a tolerably strong proof that the creation of our own species is a comparatively recent event, and one posterior (generally speaking) to all the great natural transactions chronicled by geology.[283]

Vestiges adheres to a uniformitarian interpretation that geological history is the result of causes still in operation: "If there is anything more than another impressed on our minds by the course of the geological history, it is, that the same laws and conditions of nature now apparent to us have existed throughout the whole time…"[284] Yet, in opposition to strict uniformitarianism as formulated by Lyell, *Vestiges* proclaims a progressive gradation of living things:

> In pursuing the progress of the development of both plants and animals upon the globe, we have seen an advance in both cases, along the line leading to the higher forms of organization…. Indeed, the doctrine of the gradation of animal forms has received a remarkable support from the discoveries of this science…"[285]

And now the author treads carefully. Throughout the early chapters of *Vestiges*, our guide through this panorama of natural history has adhered to principles of natural theology (although deistically inclined), and that is now reaffirmed:

> That God created animated beings, as well as the terraqueous theatre of their being, is a fact so powerfully evidenced, and so universally received, that I at once take it for granted. But in the particulars of this so highly supported idea, we surely here see cause for some re-consideration. If may now be inquired, — In what way was the creation of animated beings effected?[286]

Vestiges is about to make a particularly daring plunge into the origins of life itself.

Based on what *Vestiges* has presented so far about the inorganic world, the reader understands that it is "the result, not of any immediate or personal exertion on the part of the Deity, but of natural laws which are expressions of his will." The organic realm must be similar. Natural law must also govern all living things, including the first manifestations of life. The author acknowledges how unusual this line of thinking is, for "the inquiry is into

---

[282] [Chambers], Vestiges, p. 98.
[283] Ibid, p. 144.
[284] Ibid, p. 146.
[285] Ibid, pp. 148, 149.
[286] Ibid, pp. 152–153.

one of nature's profoundest mysteries, and one which has hitherto engaged no direct attention in almost any quarter."[287]

Vestiges then cites the research of Andrew Crosse, whose experiments in crystallization using electricity had an accidental outcome, which "seemed to result in the production of a heretofore unknown species of insect in considerable numbers."[288] Some follow-up experiments confirmed this phenomenon. A natural law must therefore exist that allows living things to arise spontaneously in certain conditions through applications of electricity.

Vestiges now addresses "the obvious gradation amongst the families of both the vegetable and animal kingdoms, from the simple lichen and animalcule respectively up to the highest order of dicotyledonous trees and the mammalia." This "fundamental unity" of life "must have depended upon one law or decree of the Almighty, though it did not all come forth at one time."[289] Like Lamarck, the author of *Vestiges* will search for a law that allows new species to come into existence by something other than miraculous fiat.

One intriguing solution to this problem is revealed by examining the development of the embryos of various animals between conception and birth: "It is only in recent times that physiologists have observed that each animal passes, in the course of its germinal history, through a series of changes resembling the permanent forms of the various orders of animals inferior to it in the scale."[290] This series of embryonic changes parallels the gradation of species.

> Nor is man himself exempt from this law. His first form is that which is permanent in the animalcule. His organization gradually passes through conditions generally resembling a fish, a reptile, a bird, and the lower mammalia, before it attains its specific maturity. At one of the last stages of his fœtal career, he exhibits an intermaxillary bone, which is characteristic of the perfect ape; this is suppressed, and he may then be said to take leave of the simial type, and become a true human creature."[291]

In the early 20th century, this idea would be summed up by the catchy phrase "ontogeny recapitulates phylogeny."

The suggestion here is that if a pregnancy is extended, then the result would be an organism of a slightly more advanced state. But it can't be that easy, for "what we ordinarily see of nature is calculated to impress a conviction that each species invariably produces its like."[292] There must be another factor controlling development.

At this point, *Vestiges* turns to Charles Babbage and his *Ninth Bridgewater Treatise*, quoting a four-page extract of the description of that calculating machine as it cranks out a

---

[287] Ibid, pp. 154, 165.
[288] Ibid, p. 185.
[289] Ibid, p. 191, 197.
[290] Ibid, p. 198.
[291] Ibid, p. 199.
[292] Ibid, pp. 205-6.

sequence of successive natural numbers. Long after the sequence has gone on for so long that everyone agrees on the establishment of a natural law, the machine suddenly exhibits an apparent change.

Similarly, a species "is capable of advancing by generation to a higher type of being.… Mr. Babbage's illustration powerfully suggests that this ordinary procedure may be subordinate to a higher law which only *permits* it for a time, and in proper season interrupts and changes it." In this way, a "transition from species to species"[293] is achieved.

> Thus, the production of new forms, as shewn in the pages of the geological record, has never been anything more than a new stage of progress in gestation, an event as simply natural, and attended as little by any circumstances of a wonderful or startling kind, as the silent advance of an ordinary mother from one week to another of her pregnancy.[294]

Vestiges is careful to distinguish this theory from the mechanism that Lamarck proposed for the transformation of species. The author is well aware of Lamarck's reputation among mainstream naturalists, and he dismisses Lamarck with the same prejudice: Lamarck's theory "deservedly incurred much ridicule," and is inferior to "the simple and easily conceivable aid of a higher generative law."[295]

Vestiges then spends a chapter exploring the quinarian system of species classification of William Sharp Macleay, where everything is arranged in circular groups of five. Each of the five kingdoms has five sub-kingdoms, each of which has five classes, each of which contains five orders, and each order has five tribes. When this is done, the order Bimana — those primates with two legs and two arms — contains only one tribe: Homo.[296] Four slots in Bimana are unoccupied.

This leads *Vestiges* into one of its most thrilling speculations, proposing that humans can further progress to new types of humanity:

> It may be asked, — Is the existing human race the only species designed to occupy the grade to which it is here referred? … Is our race but the initial of the grand crowning type? Are there yet to be species superior to us in organization, purer in feeling, more powerful in device and act, and who shall take a rule over us? … There may then be occasion for a nobler type of humanity, which shall complete the zoological circle on this planet, and realize some of the dreams of the purest spirits of the present race.[297]

This advance could be physical, but likely manifested more acutely in the mental and moral faculties. Here's where the materialism of *Vestiges* is most apparent: The author doesn't make a distinction between physical and mental, and moreover, he treats the

---

[293] Ibid, pp. 211, 214.
[294] Ibid, pp. 222–223.
[295] Ibid, p. 230–231
[296] An illuminating illustration is provided in Secord, *Victorian Sensation*, p. 387.
[297] [Chambers], *Vestiges*, p. 276.

mental and moral constitution of mankind as being of the same type that we see in animals because both arise solely from physical attributes. "There is a general disinclination to regard mind in connexion with organization, from a fear that this must needs interfere with the cherished religious doctrine of the spirit of man, and lower him to the level of the brutes." Nevertheless, the author perceives continuity and gradation between these brutes and man, as well as a regularity in moral behavior that comes "under the presidency of law. Man is now seen to be an enigma only as an individual; in the mass he is a mathematical problem"[298] analyzable with statistics.

Perhaps what readers appreciated most in *Vestiges* is the simplicity of its reductionist vision:

> It is most interesting to observe into how small a field the whole of the mysteries of nature thus ultimately resolve themselves. The inorganic has one final comprehensive law, GRAVITATION. The organic, the other great department of things, rests in like manner on one law, and that is, — DEVELOPMENT.[299]

It's always nice to have a single word to sum up an entire worldview, and *development* is a good one.

Vestiges was published anonymously. Anonymous publication was common for novels and poems and reviews in periodicals, but not for works of science. Science books required an author with authoritative letters after his name, which made the anonymous publication of *Vestiges* rather disturbing. Speculating who the author might be became a popular parlor game of the season. It was well known that anonymous authors weren't hesitant to quote themselves, so Charles Lyell was a possibility; or Charles Babbage; or the popularizer of the nebular hypothesis, John Pringle Nichol; or that reclusive but prolific epistolarian, Charles Darwin.[300]

Yet, the book contained several red flags indicating that the author was not a mainstream man of science. Popping up throughout *Vestiges* were startling bursts of pseudo-science and weirdness: Spontaneous generation! Fetal development! Transmutation! Calculating machines! Quinarian species classification! Even a footnote referencing the *Phrenological Journal*![301] To men of science themselves, the author seemed to be a well-read but not very discriminating amateur. In what we would now call a "gendered reading" of *Vestiges*, some readers detected a woman's hand in its enticing seductive style. Perhaps the novelist Catherine Crowe, or the firebrand journalist Harriet Martineau, or Lord Byron's well-educated daughter Ada, countess of Lovelace, who was known to be quite familiar with Babbage's Analytical Engine.

Eventually, the most likely suspect became Robert Chambers, who with his brother William ran a prolific and highly regarded publishing house out of Edinburgh. Some of Robert Chambers other writings seemed to oddly coincide with passages from *Vestiges*, but

---

[298] Ibid, pp. 325, 331.
[299] Ibid, p. 360.
[300] Secord, *Victorian Sensation*, pp. 21, 466.
[301] [Chambers], *Vestiges*, p. 346.

he never admitted that he was the author. He recognized the potentially inflammatory nature of what *Vestiges* represented, and he feared the loss of his business and repercussions for his family. Robert Chambers was only positively identified as the author of *Vestiges* in the 12th edition published in 1884, thirteen years after his death.

To many clerics, *Vestiges* presented a dangerously materialist vision of the universe and of living things, differentiating between man and the "brutes" solely by gradations of development. They warned their flocks but to no avail. In providing a big picture of the universe and humanity, the book was enormously popular, and it was discussed wherever literate people met and talked. *Vestiges* was (as historian James Secord titled his superb history of the book) a *Victorian Sensation*: "The specter of Frankenstein haunted the *Vestiges* sensation. The book was a generic monster, the progeny of all the literary experiments that made reading so exciting."[302]

Even Queen Victoria and Prince Albert — still in their 20s and already the parents of four children — were enjoying *Vestiges*. In early 1845 Alfred would spend some time in the afternoons reading the book aloud to Victoria. "With its accessible presentation and attractive narrative, the book served much the same function in their domestic relations as did the scientific talks later given in the palace to the royal children. *Vestiges* could make science a shared interest."[303]

For some, *Vestiges* was one of several influences contributing to religious doubt. The young poet Arthur Hugh Clough expressed his fading faith in witty verse:

> And as of old from Sinai's top,
> God said that God is One,
> But Science strict so speaks He now
> To tell us, There is None!
> Earth goes by chemic forces; Heaven's
> A Méchanique Céleste!
> And heart and mind of human kind
> A watch-work as the rest![304]

Abraham Lincoln was also a reader of *Vestiges* and according to his law partner and biographer William Henry Herndon, Lincoln "became a warm advocate of the doctrine."[305]

Born on the same day as Lincoln in 1809, naturalist Charles Darwin read *Vestiges* "in the bustling, flea-infested British Museum library"[306] in a completely different frame of mind. He was afraid at first that the author might have stumbled on the same mechanism of natural selection that he had been developing since his return from the voyage of the *Beagle* eight years earlier. Just that past summer, Darwin had outlined his theory in an unpublished essay that he shared with just a few select confidants. Much of the thrust of

---

[302] Second, *Victorian Sensation*, p. 41.
[303] Secord, *Victorian Sensation*, p. 169.
[304] Quoted in Secord, *Victorian Sensation*, p. 254.
[305] Quoted in Secord, *Victorian Sensation*, p. 38.
[306] Ibid, p. 429.

Vestiges seemed to parallel what Darwin had been planning for his big book on species, but it was nowhere close in tone or caution. Darwin's biographer writes:

> *Vestiges* was journalistic, lively, all-encompassing. More than that, it addressed all the questions about man's relations with animals and God which naturally emerged from a transmutationist argument, all the moral questions Darwin carefully avoided in his own essay. Thankfully Darwin saw that *Vestiges'* treatment of these urgent themes, and its author's eagerness to accept the most astonishing stories as genuine, were the book's undoing in the eyes of high science.[307]

Indeed, many other prominent men of science were unnerved by how *Vestiges* had recklessly usurped their authority in promiscuously synthesizing unrelated areas of research.[308] Their first instinct was to simply ignore the book in hopes that it would go away, but it did not.

Vestiges also harbored a political undercurrent: By the 1840s, radical working-class movements in England had gone beyond the deism of Thomas Paine's *Age of Reason* and in some cases had embraced outright atheism. The street literature of this freethinking underground included publications such as the illegal penny newspaper *Oracle of Reason*, published between 1841 and 1843. *Oracle* promoted democracy, atheism, and science while condemning "kingcraft," "priestcraft," and the Bible, and landing its successive editors in jail for blasphemy. Integral to the radical politics of this movement was the promotion of a Lamarckian transmutation of species — often characterized as "regular gradation" — that was used to bolster the concepts of political and social progress. Just as species can transform by forces within themselves striving for something better, society could be made to transform by its own internal radical forces.[309]

It was important that *Vestiges* be condemned. Countering its influence meant not only taking a stand for the integrity of the vocation of authoritative men of science, but it would also help promote political moderation and societal stability.

One of the first anti-*Vestiges* tracts was the short book *Indications of the Creator*,[310] by William Whewell, who was now Master of Trinity College, and Professor of Moral Philosophy at Cambridge. *Indications of the Creator* was mostly excerpts from Whewell's previous books, *History of the Inductive Sciences* (1837), *Philosophy of the Inductive Sciences* (1840), and his Bridgewater Treatise, much of it arguing against transmutation of species, and in favor of the primacy and uniqueness of God's foremost creation: "The Instinct of animals cannot become the Reason of man, by any process of development. We

---

[307] Browne, *Voyaging*, p. 461.
[308] Richard Yeo, "Science and Intellectual Authority in Mid-Nineteenth-Century Britain: Robert Chambers and *Vestiges of the Natural History of Creation*," *Victorian Studies*, Vol. 28, No. 1 (Autumn, 1984), pp. 5–31.
[309] Adrian Desmond, "Artisan Resistance and Evolution in Britain, 1819–1848," *Osiris*, 2nd series, Vol. 3 (1987), pp. 77–110.
[310] William Whewell, *Indications of the Creator* (London: John W. Parker, 1845), https://books.google.com/books?id=YW9CAQAAMAAJ.

cannot unfold the mind of a spider or a bee into the mind of a geometer."[311] To Whewell, some questions are far beyond science, for

> geology and astronomy are, of themselves, incapable of giving us any distinct and satisfactory account of the origin of the universe, or of its parts. We need not wonder, then, at … the impossibility of accounting by any natural means for the production of all the successive tribes of plants and animals which have peopled the world in the various stages of its progress, as geology teaches us. That they were, like our own animal and vegetable contemporaries, profoundly adapted to the condition in which they were placed, we have ample reason to believe; but when we inquire when they came into this our world, geology is silent. The mystery of creation is not within the range of her legitimate territory; she says nothing, but points upwards.[312]

Somewhat to the annoyance of his critics, the author of *Vestiges* seemed willing to learn from their critiques, and he responded with corrections and elaborations. He quickly wrote a second book called *Explanations* that provided additional scientific background to *Vestiges*, and he addressed some issues raised by Whewell in his book.

Where *Vestiges* was likely to be discussed by large groups of scientists was the annual meeting of the British Association for the Advancement of Science. But what would the reaction be?

The June 1845 meeting of the BAAS took place that year in Cambridge, and began as usual with an address by the newly appointed president. This year it was John Herschel, who had become much more than the only son of William Herschel. He had written the influential *Preliminary Discourse on the Study of Natural Philosophy* in 1830 (one of young Charles Darwin's inspirations) and the popular *Treatise on Astronomy* in 1833, and after a long trip to the southern hemisphere "had become — and would remain — the only astronomer in history to examine the entire heavens with a major telescope."[313] John was more restrained than his father, less given to public speculation,[314] and he maintained more mainstream ideas about religion and natural theology.

Early on in his president's address[315], Herschel seems to be alluding to *Vestiges* when he criticizes "the propensity to crude and over-hasty generalization."[316] But he moved on, and cited as one of the year's achievements the work done with the Earl of Rosse's new six-foot reflecting telescope. Like his father, John is very much interested in nebulas and

---

[311] Ibid, Preface, p. xx.
[312] Ibid, pp. 70–71.
[313] Michael Hoskin, "John Herschel's Cosmology," *Journal for the History of Astronomy*, Vol. 18 (1987), pp. 1–34, quote on p. 23.
[314] Ibid, pp. 5, 7.
[315] "Address by Sir John F. W. Herschel," *Report of the Fifteenth Meeting of the British Association for the Advancement of Science* (London: John Murray, 1846), pp. xxvii–xliv.
[316] Ibid, p. xxviii.

nebulous matter, which leads into the statement "Much has been said of late of the Nebulous Hypothesis, as a mode of representing the origin of our own planetary system." [317]

The *nebulous* hypothesis? Not the *nebular* hypothesis? Is that a joke? The word *nebulous* could mean the same as *nebular*, but it also refers to something vague or malformed.

Herschel attributes the hypothesis to Laplace and has no problems with it "as a matter of pure speculation." But "if it is to be regarded as a demonstrated truth … I beg leave to demur." He alludes to "a philosophical work of much mathematical pretension" that touches upon the subject. He did not mention the title when delivering the address, but a footnote in the published version identifies it as Auguste Comte's *Cours de Philosophie Positive*. Comte had developed what purported to be a mathematical proof of the nebular hypothesis, but Herschel attacks that math, and asks "is there a student to be found who has graduated as a Senior Optime in this University, who will not at once lay his finger on the fallacy of such an argument, and declare it a vicious circle?" Yet, Comte's argument has been "eagerly received among us as the revelation of a profound analysis," and another footnote identifies John Stuart Mill's *A System of Logic* as well as *Vestiges* as the books that cited Comte.[318]

In another not-quite-overt reference to *Vestiges* and the development theory in general, Hershel identifies as an "evil" how natural laws have seemingly usurped the creator of those laws, how

> *law* is brought so prominently forward as not merely to throw into the background that of *cause*, but almost to thrust it out of view altogether…. as when we are told, for example, that the successive appearances of races of organized beings on earth, and their disappearance, to give place to others, which Geology teaches us, is a result of some certain law of development, in virtue of which an unbroken chain for gradually exalted organization … up to the monkey and the man (nay, for aught we know, even to the angel), has been (or remains to be) evolved.[319]

Robert Chambers and his wife Anne had come to Cambridge for the BAAS meeting, and they sat in the front row for Herschel's address, but no one knew he was the author of *Vestiges*, and the couple left Cambridge with a newly formed distaste for exclusivity of establishment science.[320]

Following soon upon the BAAS meeting was Adam Sedgwick's anonymous review of *Vestiges* in the July 1845 issue of *The Edinburgh Review*.[321] In 85 dense and blistering

---

[317] Ibid, p. xxxviii.
[318] Ibid, pp. xxxviii–xxxix.
[319] Ibid, p. xlii.
[320] Secord, *Victorian Sensation*, pp. 383ff.
[321] [Adam Sedgwick], "Vestiges of the Natural History of Creation," *The Edinburgh Review or Critical Journal*, Vol. LXXXII, No. CLXV (July 1845), https://books.google.com/books?id=tGAJAAAAQAAJ, pp. 1–85.

pages — nearly half the length of *Vestiges* itself[322] — the review begins by calling the book "remarkable" and enjoying "a sudden run of public favour," but quickly turns to mocking it for its conclusions ("that Monkeys will … become at length the parents of Men") and within the first three pages characterizing the author with savagery: "the peculiar qualities of our author's mind … everything is touched upon, while nothing is firmly grasped … shallow … second-hand … misconceiving the principles of science … trashy skimmings of philosophy … the philosophy of the author is borrowed from a false and shallow School … nothing better than mischievous, and sometimes antisocial, nonsense … the serpent coils of a false philosophy … a rank, unbending, and degrading materialism …"[323]

Sedgwick was one of those readers who entertained a gendered reading of *Vestiges*, which he now makes disturbingly explicit:

> We thought, when we began to 'The Vestiges' that we could trace therein the markings of a woman's foot. We now confess our error; and for having entertained it, we crave pardon of the sex. We were led to this delusion by certain charms of writing — by the popularity of the work — by its ready boundings over the fences of the tree of knowledge, and its utter neglect of the narrow and thorny entrance by which we may lawfully approach it; above all, by the sincerity of faith and love with which the author devotes himself to any system he has taken to his bosom. We thought that no *man* could write so much about natural science without having dipped below the surface, at least in some department of it. In thinking this, we now believe we were mistaken.[324]

This conclusion does not stop him from interpreting *Vestiges* as the work of a feminine mind. Sedgwick warns "that the ascent up the hill of science is rugged and thorny, and ill-fitted for the drapery of a petticoat." (It might be noted here that Sedgwick never married.)

While continuing to take vicious swipes at the author, Sedgwick's review shifts to the science, and he condemns the book's dabblings in phrenology, spontaneous generation, and transmutation. *Vestiges* seems to have suddenly given the nebular hypothesis a bad reputation, for Sedgwick is now skeptical as well: "All that La Place did was to show the dynamical possibility of the formation of a solar system like our own from a revolving nebula; and this is, we think, the exact condition in which he left the hypothesis" — and like John Herschel he criticizes "the somewhat ostentatious calculation of M. Comte."[325]

Sedgwick's primary focus is in denying transmutation, which he often calls "the development theory." He reviews in detail what is currently known about the fossil evidence in the various levels of strata and finds no evidence of transmutation. Using Richard Owen's recently coined word, Sedgwick contrasts the Dinosaurs that have "died away" and the mammals that have taken their place. Mammals could not have come about by a transmutation of the previous species, for they

---

[322] The first edition of *Vestiges* is about 80,000 words; the review is about 40,000.
[323] Ibid, pp. 1–3.
[324] Ibid, pp. 3–4.
[325] Ibid, pp. 21, 22.

> have no zoological base to rest upon. They were not called into being by any known law of nature, but by a power above nature. They were created by the hand of God, and adapted to the conditions of the period. This is the conclusion of Agassiz and Owen, on better evidence than Cuvier possessed: and this was in substance the grand conclusion of Cuvier; for if, as he again and again affirms, the extinct fossil species which he reconstructed with admirable skill, were not produced by any continued natural organic law from other species, then must they have been created."[326]

Sedgewick also explores what he calls "Fœtal Development" — the idea that an organism in its fetal state passes through the same series of species that contributed to its transmutationist history — and through many counter examples finds it to be "nothing but a pile of wildly gratuitous hypotheses."[327]

> We conclude, then, that our author's work is not merely shallow and superficial, but utterly false throughout to all the principles of sound philosophy. Of all the books we ever read, it puts before us the largest congeries of positive misstatements, and positively false conclusions. But it is pleasantly written, it is systematic, and it has been prepared for the press with no common care…. we are compelled (almost against our senses) to believe that the author is actually labouring under some strange delusion, whereby he cheats himself, while he is doing his best to cheat others; by turning upside down every rule of sound induction, and by affirming, again and again, and in every solemn form of language, that which is at direct variance with the plainest acknowledged facts of nature.[328]

In its unprecedented length and unbridled vehemence, Sedgwick's review was acknowledged by many to have been a tactical mistake.[329] More casual readers recognized *Vestiges* as speculation, but Sedgwick reacted with overkill by treating the book much more seriously than its readers had. His relentless badgering about the book's incompatibility with actual science took all the fun out of it.

What Sedgwick's review successfully accomplished was to serve as a warning to others who might be contemplating a book on the transmutation of species. In reading it, Charles Darwin recognized how his own theory might be attacked.[330] He concluded that it was much too early to rush those ideas into print. He would need to be very careful.

Perhaps the most unexpected appearance of *Vestiges* — or rather, a book much like it — was in a novel where to served to trigger an important plot point.

Long before he became Prime Minister in 1874, Benjamin Disraeli wrote novels, and in 1847 he published the finale of his Young England trilogy, *Tancred, or the New Crusade*.

---

[326] Ibid, pp. 60-61.
[327] Ibid, pp. 72, 74.
[328] Ibid, p. 85.
[329] Secord, *Victorian Sensation*, pp. 246–247.
[330] Browne, Voyaging, p. 469.

Upon coming of age, our hero Tancred, known more formally as Lord Montacute, is offered a perfect life with a seat in Parliament and marriage to his lovely cousin. To the shock of his parents, he rejects it all. As a thoughtful young Tory, he is greatly disturbed by England's increasing trends toward democracy and secularism. There is no sense to pursuing public service in a country that is not ordered on moral principles. Tancred must instead seek answers to his brooding thoughts by a journey to the Holy Land.

Tancred's parents are understandably alarmed. They send him to talk to the bishop, but the bishop pronounces him "a visionary." Their next step is pure genius: They decide to introduce Tancred to London society where there might be the one thing on earth that can distract an intelligent and serious young man from his overly deep thoughts.

And it works! In London Tancred is immediately smitten by a frequent denizen of Victorian novels, "a young lady, rather tall [with] a brilliant complexion, classic features, a profusion of light brown hair; a face of intelligence and a figure rich and yet graceful."[331] She has the enticing name of Lady Constance Rawleigh. There is dancing, there is light conversation, there are flutters of the heart and dreams of the future, and then a pivotal scene involving a vaguely familiar book.

Tancred is visiting Lady Constance when he picks up a book lying about with the title *The Revelations of Chaos*, "a startling work just published, and of which a rumour had reached him." Lady Constance is only too eager to share the excitement of her reading. She tells Tancred that "it is one of the books one must read. It explains everything, and is written in a very agreeable style."

Tancred is skeptical, but Lady Constance assures him: "It is treated scientifically; everything is explained by geology and astronomy, and in that way. It shows you exactly how a star is formed; nothing can be so pretty! A cluster of vapour — the cream of the Milky Way — a sort of celestial cheese — churned into light…" Tancred is certain that no one has ever seen a star being formed, but Lady Constance's enthusiasm for the book boils over:

> "But what is most interesting, is the way in which man has been developed. You know, all is development. The principle is perpetually going on. First, there was nothing, then there was something; then — I forget the next — I think there were shells, then fishes; then we came — let me see — did we come next? Never mind that; we came at last. And the next change there will be something very superior to us — something with wings. Ah! that's it: we were fishes, and I believe we shall be crows. But you must read it."
>
> "I do not believe I ever was a fish," said Tancred.
>
> "Oh! But it is all proved … by geology, you know. You see exactly how everything is made; how many worlds there have been; how long they lasted; what went before what comes next. We are a link in the chain, as inferior animals were that preceded us: we in turn shall be inferior; all that will remain of us will be some

[331] Benjamin Disraeli, *Tancred: or, The New Crusade* (1847), Book II, Chapter VI (numbered Chapter XII in some editions).

> relics in a new red sandstone. This is development. We had fins — we may have wings."[332]

This is all too much for Tancred's reactionary orthodoxy. Just moments earlier he had contemplated taking Lady Constance to the Holy Land with him as his wife, but he now recognizes the shallowness of her intellect and deficiencies of her faith. With a few quick steps, Tancred takes leave of Lady Constance, and she disappears from his life and the novel. He shall need to find love and spiritual succor elsewhere.

For Tennyson, *Vestiges* triggered a creative breakthrough. Upon hearing of the book, he wrote to his publisher to get him a copy, for "it seems to contain many speculations with which I have been familiar for years..."[333] and he said in reading it, "I trembled as I cut the leaves."[334]

Tennyson saw in *Vestiges* not a materialist universe devoid of God but a more hopeful and spiritual vision. The progressive development described in *Vestiges* seemed to herald the rise of some greater being from the current species of mankind. He went back to his poem that over the years had come to be about much more than the death of his friend. In some additional verses, Tennyson's "herald of a higher race" seems to reference "the grand crowning type" beyond man from *Vestiges*:

> Contemplate all this work of Time,
> The giant labouring in his youth;
> Nor dream of human love and truth,
> As dying Nature's earth and lime;
>
> But trust that those we call the dead
> Are breathers of an ampler day
> For ever nobler ends. They say,
> The solid earth whereon we tread
>
> In tracts of fluent heat began,
> And grew to seeming-random forms,
> The seeming prey of cyclic storms,
> Till at last arose the man;
>
> Who throve and branch'd from clime to clime,
> The herald of a higher race,
> And of himself in higher place,
> If so he type this work of time
>
> Within himself, from more to more;
> Or, crown'd with attributes of woe
> Like glories, move his course, and show

[332] Ibid, Book II, Chapter IX (numbered chapter XV in some editions).
[333] H. Tennyson, *Alfred Lord Tennyson: A Memoir*, Vol. I, pp. 222-3.
[334] Paul Turner, *Tennyson* (Routledge Author Guides; Routledge & Kegan Paul, 1976), p. 124.

That life is not as idle ore,

But iron dug from central gloom,
  And heated hot with burning fears,
  And dipt in baths of hissing tears,
And batter'd with the shocks of doom

To shape and use. Arise and fly
  The reeling Faun, the sensual feast;
  Move upward, working out the beast,
And let the ape and tiger die.[335]

Tennyson ended the poem with a description of the 1842 wedding of his sister Cecilia, suggesting that through deaths like that of Hallam's and the births of his sister's children, the world progresses towards perfection and the elimination of the "beast" within us, of that "ape and tiger" that mar our better natures.

Tennyson finished *In Memoriam* in 1849. One of the last additions was a Prologue of more traditional Christian piety, perhaps to counterbalance the religious doubt that characterized the rest of the poem. One very special reader who Tennyson needed to appeal to in this Prologue was Emily Sellwood, who Tennyson wished to marry but who was troubled by Tennyson's shaky faith. He addresses her directly within the poem and then alludes to Arthur Hallam:

You say, but with no touch of scorn,
  Sweet-hearted, you, whose light-blue eyes
  Are tender over drowning flies,
You tell me, doubt is Devil-born.

I know not: one indeed I knew
  In many a subtle question versed,
  Who touched a jarring lyre at first,
But ever strove to make it true:

Perplext in faith, but pure in deeds,
  At last he beat his music out.
  There lives more faith in honest doubt,
Believe me, than in half the creeds.[336]

If someone as "pure in deeds" as Hallam was also as "perplext in faith" as Tennyson, surely Emily could accept these flaws in a husband.

In Memoriam was published on June 1, 1850. It was a very good year for Tennyson. He and Emily were married later that month. (Their first child would be named Hallam, who would write a two-volume *Memoir* of his father's life late in the century.) In December,

---

[335] Tennyson, *In Memoriam*, canto CXVI, pp. 182–183.
[336] Ibid, canto XCIV, p. 142.

Tennyson became Poet Laureate, taking over from William Wordsworth, who had died earlier in in the year. It was a position Tennyson would hold until his death in 1892. The decision to award this honor to Tennyson was based largely on *In Memoriam*, which convinced Prince Albert that Tennyson was now the greatest of English poets. Despite at least one critic who identified the book's irreligious nature, *In Memoriam* became a popular source of comfort for Victorians dealing with death and grief, including Queen Victoria herself following the death of Albert in 1861. "Next to the Bible In Memoriam is my comfort,"[337] she told Tennyson.

"There lives more faith in honest doubt, / Believe me, than in half the creeds." Religious doubt had landed on Victoria's bedside and entered the Victorian mainstream.

It was not only geology and the materialism of *Vestiges* that contributed to the decline of Biblical literalism and the rise of religious doubt. In Germany, research was advancing that was initially unknown to many English men and women. German scholars, mostly associated with the University of Tübingen, had laid the Bible open on the dissection table, and were probing its interior with the sharpened tools of historical-critical analysis. From this "higher criticism" (as it was called) came a startling book by theologian David Friedrich Strauss called *Das Leben Jesu, kritisch bearbeitet* — "The Life of Jesus, critically examined." Originally published in 1835 and 1836, by 1840 the two volumes of the fourth edition totaled just short of 1500 pages.

The title of Strauss's book is not quite accurate. Rather than a life of Jesus, the book is instead an extremely detailed demonstration that a trustworthy account of this life is impossible given the nature of the source material. Strauss meticulously dissects the four gospels attempting to extract accurate narratives, only to find internal inconsistencies, contradictions, and implausible events. The accounts of miracles in particular leave him skeptical. They often seem unworthy of God. Earlier analyses of the gospels had assumed either that tales of miracles were truly supernatural events, or resulted from the faulty or misunderstood eyewitness testimony of natural occurences. Strauss rejects both the supernatural and natural explanations, and instead interprets the gospels as mostly myths fabricated to reinforce the legitimacy of Old Testament prophecy. If, for example, Micah 5:1-2 suggested that the Messiah would be born in Bethlehem, that's where Matthew and Luke place his birth, although Strauss is quite sure that Jesus was really born in his parent's home in Nazareth.

An early English translation of Strauss's book in a cheap edition for working-class radicals was in progress — Friedrich Engels reported that it was popular among the Manchester proletariat[338] — but a complete authoritative translation was sorely needed. It was a big job, and after being tossed around among a circle of several young freethinkers, it landed on the desk of Mary Ann Evans, 24 years old, whip smart, and eager to work.

---

[337] H. Tennyson, *Alfred Lord Tennyson: A Memoir*, p. 485.
[338] Friedrich Engels, *Die Lage der arbeitenden Klasse in England* (Leipzig: Otto Wigand, 1845), https://books.google.com/books/books?id=j1pdAAAAcAAJ, p. 288.

In her teenage years, Mary Ann Evans had a period of very strong evangelical faith, but partly as a result of extensive reading in philosophy and the sciences, her religion had become more individualistic and less conventional. At the age of 22 in a letter to her father, she declared a "holy war" and announced that she would no longer go to church. She said that the scriptures were "histories consisting of mingled truth and fiction" from which doctrines were derived "to be most dishonourable to God and most pernicious in its influence on individual and social happiness."[339]

The young Mary Ann Evans exemplified what one scholar calls an "ethical revolt" against the orthodox Christianity of the period, a rejection of primitive doctrines such as original sin, vicarious atonement, and eternal punishment.[340] "I cannot rank among my principles of action a fear of vengeance eternal, gratitude for predestined salvation, or a revelation of future glories as a reward,"[341] Evans wrote to a friend. These Christian concepts of otherworldly salvation were at odds with the seemingly more ethical goals of progressive human betterment and societal improvement.

Evans found that translating Strauss's life of Jesus was slow and brutal work, a "soul-stupefying labour,"[342] and not only because of the book's length. Strauss's scholarly savagery offered nothing to compensate for his relentless analysis and subsequent destruction of every element of the gospels that had nurtured Evans' early life and, indeed, the past eighteen centuries of Christian Europe. She kept both an engraving of Christ and an ivory image of the crucifixion at her desk while she worked, and a friend reported "She said she was Strauss-sick — it made her ill dissecting the beautiful story of the crucifixion, and only the sight of her Christ-image and picture made her endure it."[343] Three months later, on the eve of publication, Mary Ann seemed to have somewhat recovered when she wrote "I do really like reading our Strauss — he is so klar und ideenvoll but I do not know *one* person who is likely to read the book through, do you?"[344]

After two years of labor, *The Life of Jesus, Critically Examined* was published in 1846 with the translator's name left anonymous. Mary Ann Evans was paid only £20 for her work, but it did bring her to the attention of a publisher who would later bring out the novels that she wrote to great acclaim under the pseudonym of George Eliot. These novels would often feature religious characters and themes, but with an idiosyncratic Comte-influenced religion of humanity that became more influential than traditional Christianity.

Among those George Eliot befriended was Herbert Spencer, an influential philosopher of the Victorian era who applied progressive development to his other fields of study. In an 1852 essay entitled "The Development Hypothesis," Spencer compares the reasonableness of transmutation and creation:

---

[339] *The George Eliot Letters*, ed. Gordon S. Haight, Vol. I (Yale University Press, 1954), p. 128
[340] Howard R. Murphy, "The Ethical Revolt Against Christian Orthodoxy in Early Victorian England," *The American Historical Review*, Vol. 60, No. 4 (July 1955), pp. 800–817.
[341] *George Eliot Letters*, Vol. I, p. 125.
[342] Ibid, p. 185.
[343] Ibid, p. 206.
[344] Ibid, p. 218.

> Those who cavalierly reject the theory of Lamarck and his followers, as not adequately supported by facts, seem quite to forget that their own theory is supported by no facts at all.… [W]e may safely estimate the number of species that have existed, and are existing on the earth, at no less than ten million. Well, which is the most rational theory about these ten million of species? Is it most likely that there have been ten millions of special creation? Or is it most likely that by continual modifications, due to change of circumstances, ten millions of varieties may have been produced, as varieties are being produced still?... Should the believers in special creation consider it unfair thus to call upon them to describe how special creations take place, I reply, that this is far less than they demand from the supporters of the development hypothesis.[345]

In an 1858 volume of his collected essays, Spencer cleverly changed "the theory of Lamarck and his followers" to "the Theory of Evolution,"[346] but it was still a year before *Origin of Species*.

Other writers of the era bemoaned the gradual disappearance of faith from Victorian life. In 1850, Charles Dickens used his weekly journal *Household Words* to characterize an age that "is so perverse, and is so very short of faith — in consequence, as some suppose, of there having been a run on that bank for a few generations."

This is preparation for Dickens' discussion of the recent unveiling of Pre-Raphaelite artist John Everett Millais' painting *Christ in the House of his Parents*. As with traditional paintings of religious scenes, Millais' work is drenched with religious symbolism: the young John the Baptist is carrying a bowl of water. The young Jesus has injured his palm with a nail, and some blood has dripped onto his foot. Sheep graze outside in the background, and the interior scene is overseen by a dove.

What made the painting so controversial is that everything is portrayed with an intensely coarse and rustic realism. Nothing has a glow of holiness. Without a title and a cheat sheet to the symbolism, the scene might not be identifiable as anything other than an ancient carpenter's shop. Like Strauss's *Life of Jesus*, the painting portrays an empirical scientific examination of the truth within the myth. But for Charles Dickens it was "the lowest depths of what is mean, odious, repulsive, and revolting."

> You behold the interior of a carpenter's shop. In the foreground of that carpenter's shop is a hideous, wry-necked, blubbering, red-headed boy, in a bed-gown; who appears to have received a poke in the hand, from the stick of another boy with whom he has been playing in an adjacent gutter, and to be holding it up for the contemplation of a kneeling woman, so horrible in her ugliness, that (supposing it were possible for any human creature to exist for a moment with that dislocated throat) she would stand out from the rest of the company as a Monster, in the vilest cabaret in France, or the lowest gin-shop in England. Two

---

[345] [Herbert Spencer], "The Haythorne Papers: No. II. – The Development Hypothesis," *The Leader*, Vol. III, No. 104 (March 20, 1852), p. 280.
[346] Herbert Spencer, *Essays: Scientific, Political, and Speculative* (London: Longman, 1858), https://books.google.com/books?id=kNnSDD5dFUYC, p. 389.

> almost naked carpenters, master and journeyman, worthy companions of this agreeable female, are working at their trade; a boy, with some small flavor of humanity in him, is entering with a vessel of water; and nobody is paying any attention to a snuffy old woman who seems to have mistaken that shop for the tobacconist's next door, and to be hopelessly waiting at the counter to be served with half an ounce of her favorite mixture. Wherever it is possible to express ugliness of feature, limb, or attitude, you have it expressed. Such men as the carpenters might be undressed in any hospital where dirty drunkards, in a high state of varicose veins, are received. Their very toes have walked out of Saint Giles's.[347]

John Ruskin, the art critic who was the greatest champion of the Pre-Raphaelite painters, wrote in a letter in 1851,

> You speak of the Flimsiness of your own faith. Mine, which was never strong, is being beaten into mere gold leaf, and flutters in weak rags from the letter of its old forms; but the only letters it can hold by at all are the old Evangelical formulae. If only the Geologists would let me alone, I could do very well, but those dreadful Hammers! I hear the clink of them at the end of every cadence of the Bible verses.[348]

Victorians would struggle with faith for the remainder of the century. While often manifested as individual and personal crises, these struggles nevertheless formed a trend that defined the era. Geology probably didn't play a major part in the Victorian crisis of faith, but as Ruskin acknowledged, it was a factor.

The geological revolution began with Buffon in 1749, or perhaps James Hutton in 1785, or perhaps it was an inevitable outcome of the consecration of natural law by Descartes and Newton. But by 1850, the revolution was mostly over. Mosaic chronology had faded away with much less bloodshed than the Reformation, and less anguish than the Copernican revolution. According to one prominent historian of the Victorian church, by the 1850s educated clergymen "were saying that for many years no man of sense had believed in a creation of the world during six days of twenty-four hours."[349]

People still used words like "antediluvian" and "pre-Adamite" to refer to ancient ages, but among the learned, the terms had become much less literal.[350] For others, of course, they still retained their Biblical sense although the timeframe had become much more amorphous.

In 1854, life-size replicas of dinosaurs and other extinct animals were constructed near the relocated Crystal Palace following the Great Exhibition. (The sculptures still exist although the Crystal Palace does not.) There seemed to be some confusion among tourists

---

[347] "Old Lamps for New Ones," *Household Words*, Vol. 1, No. 12 (June 15, 1850), https://books.google.com/books?id=_TMFAAAAQAAJ, pp. 265-6.
[348] *The Works of John Ruskin* (London: George Allen, 1909), https://books.google.com/books?id=caOaAAAAIAAJ, p. 115.
[349] Owen Chadwick, *The Victorian Church*, Part I, second edition, p. 563.
[350] Rudwick, *Scenes from Deep Time*, p. 128.

whether these were remnants of actual animals, and some visitors began extracting teeth to take home as souvenirs. The journalist Harriet Martineau overhead a visitor to the exhibit explaining to a comrade that these were "antediluvian animals … they were too large to go into the ark; and so they were all drowned." She knew that the literate and progressive readers of the *Westminster Review* would chuckle at the visitor's naiveté, but she admonished them:

> [H]ow much better to go with an untenable theory than no ideas whatever! The mere rustic … knows nothing of the vast scenery of ages disclosed to the reverted eye of science: but the man who separates the world before the flood from the present, however erroneously, has a prodigious advantage over him. What is wanted is — more knowledge still.[351]

More knowledge still would be guaranteed in the decades to come.

The early geologists were often amateurs, and many of their names were preceded by the title Reverend. Over time, geologists had more professional profiles. Historian Frank Turner writes, "From the 1840s onward the size, character, structure, ideology, and leadership of the Victorian scientific world underwent considerable transformation and eventually emerged possessing most of the characteristics associated with a modern scientific community."[352] This increasing professionalism contributed to a decline of a religious influence within geology.

One valuable source of information about this shift is a 2004 book written by self-described young-earth creationist Dr. Terry Mortenson called *The Great Turning Point: The Church's Catastrophic Mistake on Geology — Before Darwin*. Dr. Mortenson's thesis is that Christians made a mistake in abandoning Mosaic chronology and allowing geologists to control the narrative. However, the book's parade of Biblical literalists peters out well before 1850. Echoing Frank Turner, Mortenson writes:

> by the late 1830s geology was rapidly on its way to becoming a full-time vocation and institutionally trained profession, it is little wonder that, as far as I could ascertain, no new geologically competent scriptural geologist arose in the 1840s and 1850s to continue to defend the view after the most geologically informed defenders died or were focused on other fields of study. Some men did write in opposition to old-earth theories, but they were clergymen, laymen, or scientists in non-geological fields.[353]

Books and pamphlets that sought to reconcile Genesis and geology continued, but they were no match for the power, persuasion, and scientific literacy of Charles Lyell, or the sheer excitement of *Vestiges of the Natural History of Creation*.

---

[351] [Harriet Martineau], "The Crystal Place," *Westminster Review*, Vol. 62 (October 1854), pp. 534–550, p. 540.
[352] Frank Turner, "The Victorian Conflict between Science and Religion: A Professional Dimension," *Isis*, Vol. 69, No. 3 (Sep., 1978), pp. 361–2.
[353] Dr. Frank Mortenson, *The Great Turning Point: The Church's Catastrophic Mistake on Geology — Before Darwin* (Arizona: New Leaf Publishing Group, 2004), p 221.

Dr. Mortenson barely mentions the most notorious defender of Genesis in the 1850s. This was Philip Henry Gosse, a self-taught and religiously oriented naturalist of great accomplishment and renown. He had spent his bachelor years travelling to Newfoundland, Lower Canada, Alabama, and Jamaica, with each location becoming interested in new wonders of the natural world while honing his skills as a talented and indefatigable observer and an astute writer.

Gosse wrote his first book, *The Canadian Naturalist*, in 1840 as a series of imaginary conversations between a father and son during their seasonal walks through the wilds of Lower Canada. His *Letters from Alabama* (written in 1838 but not published until 1859 on the eve of the American Civil War) describe many species of butterflies as well the horrors of slavery that Gosse witnessed firsthand. *The Birds of Jamaica* (1847) established Gosse as "the father of Jamaican ornithology."[354]

Upon acquiring a new microscope in 1849, Gosse began examining drops of pond water and became fascinated by the microscopic infusoria and rotifera that he saw. These observations were incorporated into his book *Evenings at the Microscope; or, Researches among the Minuter Organs and Forms of Animal Life* (1859). In 1852, after moving his new family to the seashore of South Devon, Gosse soon established himself as an expert on sea-anemones and corals. He began experimenting with keeping sea creatures alive in a tank of water. This had been done before, but Gosse was the person who called his tank an "aquarium" and described it in the books *The Aquarium: An Unveiling of the Wonders of the Deep Sea* (1854) and the follow-up *A Handbook to the Marine Aquarium: Containing Practical Instructions for Constructing, Stocking, and Maintaining a Tank, and for Collecting Plants and Animals* (1855), sparking an aquarium fad in 1850s England.

From the very outset, Gosse looked upon the study of Nature as a religious activity. On the first two pages of the Preface of his first book, Gosse refers to "the smiling face of Nature, the harmony and beauty of the works of God" and the "testimony borne to the wisdom and goodness of our beneficent Creator." He later observes "how admirably every creature is adapted for the situation in which it is placed, and that no situation is so barren but that it may be made to afford life and sustenance to some order of sentient beings."[355]

In *The Canadian Naturalist* of 1840, Gosse accepts an old earth. He alludes to "the organic remains of this globe prior to the Adamic creation" in which are found "the mastodons, the megatheriums, the saurian giants of those days." In a footnote he clarifies that "nothing in the Word of God … opposes the commonly received opinion, that this world had an existence in a habitable state, previous to the chaos which prevailed at the commencement of the Sacred narrative."[356]

---

[354] Ann Thwaite, *Glimpses of the Wonderful: The Life of Philip Henry Gosse, 1810 – 1888* (TK: Faber and Faber, 2002), p. 125.
[355] Philip Henry Gosse, *The Canadian Naturalist: A Series of Conversations on the Natural History of Lower Canada* (London: John Van Voorst, 1840), https://books.google.com/books?id=__BhAAAAcAAJ, pp. vii, viii, 81.
[356] Ibid, pp. 17–18.

By 1857, however, and possibly under the influence of the evangelical Plymouth Brethren to which he belonged, Gosse had developed a more idiosyncratic reading of Genesis that elegantly rescued the text from the avalanche of geological evidence for an ancient world. The concept that Gosse suggested had been proposed before, but no one had ever explored the implications in such depth and precision.

The world, said Gosse, had to be created. Look around at the trees in this new garden of creation. If you cut one of them down, the cross section would reveal rings indicating its age. The tree would seem to be many years old despite having just been created. Similarly, if you examined adult individuals that were part of this creation (Grosse doesn't name them), you'd find full heads of hair, long fingernails, and all the evidence that these individuals had been born, grew, and passed through puberty. They would even have a belly button that had never been attached to an umbilical cord! Indeed, Gosse's book was named after the Greek word for navel: *Omphalos: An Attempt to Untie the Geological Knot*.

Gosse's concept certainly has a sort of indisputable logic: If a fully or partially grown living organism simply pops into existence, it is going to include a history of its growth and its past. Similarly, a newly created world would also give the appearance of age: The forest floor would be scattered with leaves that would never have fallen from its trees. Below the seemingly freshly fallen leaves would be leaves in a state of decay, and much further down, even rotting vegetation and the remains of animals that had never lived.

Goose used the word *prochronic* (literally, pre-time) to describe these remnants of Creation, and while he doesn't claim to have insight into the mind of God, he challenges the reader to deny the concept:

> Is it not possible — I do not ask for more — that, in like manner, the natural course of the world was projected in his idea as a perfect whole, and that He determined to create it at some point of that course, which act, however, should involve previous stages, though only ideal or prochronic? … Who will say that the suggestion, *that the strata of the surface of the earth, with their fossil floras and faunas, may possibly belong to a prochronic development of the mighty plan of the life-history of this world,* — who will dare to say that such a suggestion is a self-evident absurdity?[357]

That may sound tentative, but several pages later, Gosse believes that his theory has truly vindicated scripture, and he slams his uppercase conclusion at the bottom of the book's final page:

> "IN SIX DAYS JEHOVAH MADE HEAVEN AND
> EARTH, THE SEA, AND ALL THAT IN THEM IS."[358]

---

[357] Philip Henry Gosse, *Omphalos: An Attempt to Untie the Geological Knot*, London: John Van Voorst, 1857, https://books.google.com/books?id=j3U_AAAAYAAJ, pp. 345, 347. Reprinted Woodbridge, Ct: Ox Bow Press, 1998.
[358] Ibid, 372.

Omphalos was not well received. As his son, poet and critic Edmund Gosse, wrote half a century later, "The theory, coarsely enough, and to my Father's great indignation, was defined by a hasty press as being this — that God hid the fossils in the rocks in order to tempt geologists into infidelity."[359] Nor did it help Gosse's long-term reputation that Edmund's 1907 book, *Father and Son: A Study of Two Temperaments*, is a scathing account of a religiously maniacal father that is often cited as the first memoir of family dysfunction.

Not only a "hasty press" condemned Gosse's theory. Cleric and author Charles Kingsley, one of Gosse's best friends outside the Brethren, tried to be sympathetic but simply could not. In a long letter — occupying four pages in the more conventional biography of Gosse by his son — Kingsley struggles to be kind, but he confesses that agreeing with Gosse's theory would mean to Kingsley giving up "the painful and slow conclusion of five and twenty years' study of geology, and believe that God had written on the rocks one enormous and superfluous lie for all mankind."[360]

Omphalos represented a last desperate gasp of Mosaic chronology. The accumulated geological evidence for an ancient world was so strong that it simply could not be ignored. Gosse had described the only possible reconciliation of Genesis and geology that still remained: The world appeared to be millions of years old simply because God had made it that way.

By the 1850's, much had been abandoned: the Genesis narrative, the six days of creation, the short time span since Creation, the Deluge. However important these concepts had been to pious Christians of the past, they were simply irreconcilable with the rocks. What remained was a consensus that stopped well short of the more radical theories:

- The world might be old, but it wasn't eternal.
- Species are fixed; they do not exhibit tendencies to transform, transmute, develop, or progress.
- Humans came about relatively recently.
- And natural theology remains the best framework for understanding how living things have been specifically designed to be adapted to their environments.

All the elements of this consensus appear in a popular 1850 book by the Reverend David King of Glasgow. The book was commonly known as *Geology and Religion*, but the title page identifies it as *The Principles of Geology Explained, and Viewed in Their Relations to Revealed and Natural Religion*.[361]

---

[359] Edmund Gosse, *Father and Son: A Study of Two Temperaments* (1907) (London: Penguin Books, 1989), p. 104.
[360] Edmund Gosse, *The Life of Philip Henry Gosse, F.R.S.*, Kegan Paul, 1890, https://archive.org/details/lifeofphiliphenr00goss, pg. 281.
[361] David King, *The Principles of Geology Explained* (London: Johnstone and Hunter, 1850), https://books.google.com/books?id=srsTAAAAQAAJ.

It is David King's intent to lay to rest any concern and anxiety that his readers may have of the incompatibility between the findings of geology and revelation. He quotes (although not quite accurately) the now seemingly over-wrought 1785 verse of William Cowper to emphasize just how much progress has been made in only 65 years:

> Some drill and bore
> The solid earth, and from the strata there
> Extract a register by which we learn
> That He who made it, and revealed its date
> To Moses, was mistaken in its age.[362]

Largely drawing on Lyell and others, King summarizes the recent findings of geologists before considering the age of the earth: "It must, in candour, be admitted that the more eminent geologists are now united in maintaining the greater age of the earth, and that the proofs of it which they advance are not easily withstood." He discusses the characteristic extinction and replacement of species and the interpretation of this process: "To this day geologists are divided among themselves on the question whether the strata of the earth prove, or do not prove, a progress towards higher and higher perfection in organic structure." [363] He explores the different ways of reconciling the Mosaic narrative with Genesis, including the lapse of an indefinite period of time between the first and second verses, and treating the "days" of creation as long eras. Ultimately, what must remain most important is not the insignificant incompatibilities of geology and Genesis, but the strict accordance of the books of nature and scripture:

> Both teach us the being of a God; both ascribe to him the same perfections of knowledge, wisdom, power, and goodness; both tell us that he created the world, and prepared it for becoming the abode of man. Both date the creation of man about 6000 years back; and if a change so great as his introduction to the earth then took place, it is most reasonable to believe that great accompanying changes, such as are described in the first chapter of Genesis, were made on his account.[364]

Regarding the Deluge, King concedes that most geologists and many clerics have retreated considerably: "Our best expositors of Scripture are now generally of opinion that the flood, though extensive, was local."[365]

The word "miracle" was avoided by most geologists, even if they were at a loss to describe how new species appeared as old ones went extinct. David King, however, is not so hesitant. Indeed, the identification of miracles in the natural world is an intrinsic part of King's natural theology. He alludes to David Hume's famous objection against miracles "that they are incredible, because opposed to experience." Yet to King, we see miracles throughout the fossil record whenever a new species has sprung up:

---

[362] Ibid, p. x.
[363] Ibid, pp. 26, 38.
[364] Ibid, p. 45.
[365] Ibid, p. 56.

> A new creation is not provided for by the laws of nature… Yet the proof that new races have been created is ample and irrefragable; and we have thus a striking example how little *a priori* arguments against miracles avail when opposed to substantial facts and reasonable inferences.[366]

These miracles are evidence of God's continued presence and providence.

What makes David King's book more historically interesting is his family connections. Born in 1806 in Montrose Scotland, King was educated largely at the University of Edinburgh and then studied theology in Glasgow, and by 1833 he was minister of Greyfriars church there. At some point King had made the acquaintance of James Thomson, the Professor of Mathematics at Glasgow University. In 1841, King met the two adult daughters of Professor Thomson and began wooing the older, Elizabeth, a well-educated and intelligent young woman who was also a talented pencil artist. They became engaged in 1842 and married at the end of the year.

Elizabeth was the eldest of six surviving children of James Thomson. Her two younger brothers, James and William, were both enthusiasts of the physical sciences. James' interests led him to the field of engineering, but it was William's facility with mathematics that heralded greatness. At the time of his older sister's marriage to David King, William Thomson was 18 years old and attending Cambridge University. He graduated in 1845 and the following year was appointed to the Chair of Natural Philosophy at the University of Glasgow, where he taught for the next 53 years.

The Thomson family and the King family remained close and often socialized together. An 18-year age difference separated the brothers-in-law David King and William Thomson, but in 1849, David wrote in a letter

> William and I are getting on most fraternally. We were a little at a loss for a common subject of a literary character till I thought of publishing a small treatise on geology; and since that time we have been zealously discussing all the points of which I speak in my forthcoming publication.[367]

At the same time that David was writing his book on geology, William was making breakthroughs in an area of research that would rank among the most important of 19th century science: the relationship between heat and mechanical work.

William Thomson had recently invented a new word to describe this relationship. He called it *thermo-dynamic*.[368]

---

[366] Ibid, pp. 99–100.
[367] *Memoir of the Rev. David King, LL.D*, by his wife and daughter. (Glasgow: James Maclehose and Sons, 1885), p. 192.
[368] William Thomson, "An Account of Carnot's Theory of the Motive Power of Heat…," *Transactions of the Royal Society of Edinburgh*, Vol. XVI (1849), https://books.google.com/books?id=W4A4AQAAMAAJ, p. 545.