

CHAPTER ONE

Natural History and the Nature of History

Stephen Jay Gould was fundamentally concerned with the nature of history, particularly the tempo and mode (to use renowned evolutionary theorist George Gaylord Simpson's famous phrase) of historical change.¹ Does evolutionary and social history proceed in a steady, slow, and incremental manner, or does most historical change occur in occasional short bursts that lead to fundamental shifts from one era to another? Of course, there is no single answer here and no clear dichotomy: the tempo and mode of change have varied across history. It is important to understand the relative frequency of various types of change if we are to understand how the world came to be the way it is. However, as Gould often noted, how we conceptualize the nature of historical change affects our interpretation of the past, and our conceptualizations are influenced not only by evidence but by our social context.

In 1977, Gould and Niles Eldredge published an article in the scientific journal *Paleobiology* that explained how prevalent social views of the nineteenth century about the nature of history are embedded

in the natural sciences, with Darwinian gradualism in biology providing a prime example.² In the midst of the Industrial Revolution, and the social upheavals that came in its wake, older notions of stasis, of an eternal order ordained by divine providence, had given way to conceptions of historical development, the view that history has a trajectory. However, the prevailing views generally favored slow incremental change, which did not threaten the status quo with the potential for revolution. Gould and Eldredge wrote that the preference for slow change in evolutionary theory represented in part “the translation into biology of the order, harmony and continuity that European rulers hoped to maintain in a society already assaulted by calls for fundamental social change.” Charles Darwin reflected the zeitgeist in his strong preference for gradual change. In pointing to a social origin for Darwin’s preference for gradualism, Gould and Eldredge clarify: “We mention this not to discredit Darwin in any way, but merely to point out that even the greatest scientific achievements are rooted in their cultural contexts—and to argue that gradualism was part of the cultural context, not of nature.”

Gould and Eldredge presented an alternative view of historical change, one often associated with Karl Marx—a punctuational view that does not assume historical change occurs in a slow, smooth, and seamless manner. They argued that historical change occurred in many different ways, and there was no reason to assume that gradual change was more natural than rapid, even discontinuous change. They clearly noted that their theory of punctuated equilibrium,³ which had already achieved widespread recognition and generated much controversy by the late 1970s, “is a model of discontinuous tempos of change at one biological level only: the process of speciation and the deployment of species in geological time.” However, they also made clear their belief “that a general theory of punctuational change is broadly, though by no means exclusively, valid throughout biology.” Gould and Eldredge were not arguing that gradualist or punctuationalist views are either “right” or “wrong” per se, but rather, different views may have various degrees of utility in helping us to understand the patterns of nature. Their case is that the Marxian tradition’s con-

ceptualization of the nature of historical change can open our eyes to possibilities that are not readily visible from other perspectives.

Gould was committed to understanding the context in which theories emerged, and was a dedicated intellectual historian. He not only studied Darwin and other key figures in the biological sciences with great care, he also was a student of the history of geology (which was not always entirely distinct from biology—note that Darwin primarily identified as a geologist). Indeed, Gould's first published paper examined the concept of uniformitarianism developed by the great geologist Charles Lyell.⁴

Lyell was the single most important influence on Darwin's thinking about nature, and it is from him most directly that Darwin gained his commitment to gradualism. In one of the most renowned scientific books ever written, *Principles of Geology* (published in three parts from 1830 to 1833), Lyell developed his case for a reform of the science of geology based on his methodological and substantive doctrine of uniformitarianism. This profoundly important work laid the foundations for modern geology and is rightly recognized as a towering intellectual achievement by virtually all modern geologists. However, although Lyell in his development of uniformitarianism surely did a great service to the science of geology, he also, perhaps more than anyone, impressed upon the natural sciences a preference for conceiving of change as a slow and incremental process. In his advocacy for uniformitarianism, he misrepresented other contemporary theories and mixed together under the banner of uniformity a variety of disparate claims, some of which remain widely accepted by scientists as fundamentally important and others that have quietly slipped out of favor.

Gould notes that Lyell's concept of uniformity has four distinct major components, but Lyell typically neglected to make explicit the differences among them.⁵ First, Lyell argued for the spatiotemporal invariance of natural laws. This is one of the basic assumptions of modern science and was to a large extent as uncontroversial among Lyell's scientific contemporaries as it is among scientists today. In this, Lyell was merely affirming the materialist approach, which by necessity looks for natural causes of phenomena, rather than invoking spo-

radic intervention in the physical world by a capricious deity, in order to establish the independence of science from theology.

The second claim involves the uniformity of process, the assertion that only processes (such as erosion by wind or water) that can be observed to operate in the present should be used to explain events in the past. This is now, as it was then, a somewhat more controversial claim. Scientists generally agree on a preference for invoking presently observable processes to explain the past, but some scholars, particularly those in the catastrophist tradition during Lyell's time (more on this below), suggested "that some past events required the inference of causes no longer acting or acting now at markedly slower rates." Third, Lyell asserted the rate of geologic change was uniformly "slow, gradual, and steady, not cataclysmic or paroxysmal." In other words, it neither increases nor decreases dramatically in intensity, but remains roughly constant through time. This third claim is closely related to the second, and these two claims together provided the basis for Darwin's gradualism.

The fourth and final component is based on the assertion that the general configuration of the earth has remained basically the same since its formation, with only minor non-directional change—for example, while some mountains erode, others are built up so that the basic overall state of the world remains largely unchanged with time's passage. In other words, the earth is effectively in a dynamic, steady state. In this claim, Lyell was apparently assuming that terrestrial geologic processes mimicked the ahistorical characteristics of Newton's universe, as understood in Lyell's time, where the planets revolve around the sun in the same fashion they have done for eternity. Ironically, although this fourth component was part of a larger view that argued for the antiquity of the earth, in its insistence on enduring stasis it denied history in certain respects. This is the component of Lyell's uniformitarianism that is most typically ignored by modern geologists because a large body of evidence indicates that the character of the earth has changed dramatically over its history, such as the composition of the oceans and atmosphere and the location of the continents.

Counter to Lyell, catastrophists argued that a few cataclysmic events over the course of Earth's history were responsible for the major aspects of the geologic world of the present. Lyell, a master rhetorician, presented his uniformitarianism as the *scientific* alternative to catastrophism, which he characterized as a theologically motivated defense of the biblical timescale of Earth's history and of claims for God's direct intervention in worldly affairs. This characterization was highly misleading, since at the time of Lyell's writing most informed scholars, uniformitarians and catastrophists alike, accepted that the earth was ancient and sought to explain geologic history based on material causes (such as, volcanism, earthquakes). In fact, catastrophists arguably were in some respects *more* scientific than uniformitarians in that they advocated a literal interpretation of the empirical geologic record, which provided abundant evidence for catastrophic change (such as, mass extinctions). For them, the hand of God was not necessary to explain dramatic events in natural history. Instead, material forces operating during the history of Earth were enough.

Materialist explanation, then, was central to catastrophism and uniformitarianism alike. In spite of this, Lyell tried to explain away the evidence for catastrophic events by arguing for the imperfection of the geologic record, noting that geologic forces erased many pages of Earth's history as they wrote new ones. In effect, he argued that we should distrust empirical evidence, or at least temper it with a priori theoretical conceptualizations. This, of course, is not an unreasonable approach, since there is good cause to recognize the limits of empiricism. Nonetheless, however reasonable Lyell's rejection of a strict and narrow empiricism may have been, it does seem unfair of him to characterize his catastrophist opponents as *unscientific* when they often advocated a strong commitment to empiricism, which is often seen as the hallmark of science.

Properly understood, then, the uniformitarian-catastrophist debate primarily occurred *within* the scientific enterprise and was centered on contrasting materialist explanations of the tempo and mode of historical change; it was *not* principally a clash between scientists (uniformitarians) and theologians (catastrophists). It is indeed

true that many theologians were wedded to a catastrophist approach, but that should not be taken to mean that catastrophists were in general more theologically motivated than uniformitarians. It is important to remember that Lyell himself retained a religious faith, as did most scientists of his time. He resisted Darwin's evolutionary theory for years, particularly as applied to humans, and never fully accepted it, due to concerns about its religious implications. Thus, although Lyell supported a methodological break with theologians when it came to natural history, he did not oppose religious faith nor completely shield his scientific judgment from his religious convictions. Understanding this context makes it clear that interpreting the uniformitarian/catastrophist divide as a science/religion divide is highly misleading. Lyell used the scientific/theological divide as a rhetorical device to align his uniformitarianism with the spirit of the Enlightenment and to make his catastrophist opponents appear medieval, but he could not claim to have adopted a fully materialist view himself. Regardless, Lyell won the day, and his interpretation was the one generally accepted by subsequent generations of geologists.

Darwin as a young man revered Lyell, taking the first volume of the *Principles of Geology* with him on the *Beagle* and having the subsequent volumes when they were published sent to him while he was away.⁶ His intellectual commitment to gradualism was, arguably, second only to his commitment to natural selection. Darwin was an advocate of the claim generally attributed to Linnaeus: *Natura non facit saltum* (Nature does not make leaps). Like Lyell, Darwin invoked the imperfection of the fossil record to explain away apparent periods of dramatic change in geologic history, and sought to deny the reality of a handful of global mass extinctions that were followed by the "instantaneous" (in the geological sense) appearance of a suite of new species, which a literal reading of some parts of the fossil record suggested. Darwin consistently argued that extinctions and the emergence of new species were spread out in time, as organic history was the result of the accumulation of the imperceptibly small changes occurring all around us each day, where organisms struggle for their existence against one another and the physical environment.

Thus both geology (from Lyell) and biology (from Darwin) inherited a deep commitment to the view that historical change comes slowly and an explicit denial of the likelihood of occasional episodes of rapid and dramatic upheaval. As Gould and others have argued, there is substantial evidence that counters the two central claims for gradualism in Lyell's uniformitarian doctrine. First, it has become clear that there have been catastrophic events that differ *qualitatively* from presently observable forces shaping the earth. In the most striking example, over the past three decades it has become widely accepted that the impact of an asteroid (or other extraterrestrial object) on Earth was the cause of the End-Cretaceous extinction, which wiped out the dinosaurs and many other lineages. The key evidence for this conclusion (among several other important pieces of evidence) is a layer of iridium found all around the world at the Cretaceous-Tertiary boundary of the geologic record.⁷ The fact that iridium is very rare on Earth but abundant in some extraterrestrial objects strongly suggests that the source of the iridium was extraterrestrial.⁸ This is a key example of a catastrophic mechanism of change operating in the past that is distinct from forces in operation today. Counter to Lyell's assertion that only forces in operation today explain geologic history, and counter to Darwin's assertion that no mass extinctions occurred in Earth's history, it now appears nearly certain that at least one mass extinction was indeed abrupt, caused by forces not currently acting upon the earth, and not an illusion generated by an imperfect fossil record.

Second, there is also a substantially diverse body of evidence supporting the contention that forces in operation today have, at various times in the past, operated at different rates, occasionally leading to rapid change. Thus, as Marx asserted, it is necessary to understand the historical specificity of causes and events.⁹ One of the best examples of this, which Gould presents in *The Panda's Thumb*, comes from the scablands of eastern Washington State. As Gould writes, "In the area between Spokane and the Snake and Columbia rivers to the south and west, many spectacular, elongate, subparallel channel-ways [which locals refer to as coulees] are gouged through the loess and

deeply into the hard basalt itself.” It was readily recognized by geologists that glacial meltwaters had run through the coulees, and it was generally assumed that the coulees had formed from the gradual process of erosion. Challenging this gradualist assumption, in 1923 J Harlen Bretz argued, based on several unusual features of the coulees, “that the channeled scablands had been formed all at once by a single, gigantic flood of glacial meltwater.”¹⁰ Due to the prevalent gradualist bias in geology, this catastrophic hypothesis was at first widely rejected, without being given serious consideration by most geologists. Eventually, Bretz proved to be in large part correct. Evidence was subsequently discovered indicating that Lake Missoula, an extensive, ice-dammed glacial lake in Montana, had emptied abruptly when the glacier’s retreat caused the dam to burst. Furthermore, aerial photographs of the scablands showing huge ripples on the floors of some coulees, up to 22 feet high and 425 feet long, largely cinched Bretz’s case. Bretz was wrong in his initial insistence on a *single* catastrophic event—Lake Missoula re-formed and emptied several times—but he was correct that the scablands did not assume their current form as the result of slow and constant erosion. Countering Lyell’s third uniformitarian claim, Bretz helped establish that forces observed in operation today (such as erosion) have worked at dramatically different rates during certain times in the past.

The lesson to be learned here is that catastrophist claims about change in the material world are no less scientific than those of gradualism, and are widely supported by empirical evidence. The preference for gradualism common in the natural sciences, therefore, cannot be justified on scientific grounds, as Gould argued throughout his career. Rather, to some degree at least, the preference for gradualism reflects a social bias, likely stemming in part from the ideology of the social elite, for slow, predictable change and against the notion that dramatic historical change occasionally occurs in brief, revolutionary moments.

Eldredge and Gould allied themselves with the catastrophist/punctuationalist perspective in developing their theory of punctuated equilibrium, the claim that the history of most species is best charac-

terized as long periods of relative stasis, where there is only minor, non-directional change in organismal structure, punctuated by brief periods of rapid change where new species emerge from old in a geological “moment,” which may be thousands or tens of thousands of years.¹¹ In proposing this theory, Eldredge and Gould were, like catastrophists before them, arguing for a more literal interpretation of the fossil record. They were not proposing a new mechanism of change, relying on natural selection as the primary force behind evolution, but were challenging widespread gradualist assumptions about the speed with which evolution can occur. However, they did suggest that most evolutionary change occurs around the point of speciation (the moment of punctuational change). Speciation often occurs when a small population becomes isolated from a larger population for an extended period of time. The isolated and initially small population is free to diverge from the parent population as it accumulates fortuitous mutations via natural selection. In large, geographically spread out populations, selection pressure differs across the range of a species so that genetic innovations that may be favorable in one part of the range are inhibited from spreading by different selection pressure in other parts of the range. Therefore, large populations tend to remain stable or change slowly. However, in a small population, a favored mutation can spread rapidly, becoming ubiquitous in subsequent generations. The initial isolation of a population may occur due to a variety of forces: rivers changing course, island formation, and so forth. The emergence of new species, then, is in part a consequence of historical events and changing environmental conditions and can happen rapidly (in the geologic sense).

In his magnum opus, *The Structure of Evolutionary Theory*, Gould provides an extended discussion of what punctuated equilibrium and punctuational views in general suggest about the nature of history.¹² If evolution unfolds in the manner suggested by the theory of punctuated equilibrium—and Gould presents an array of evidence that suggests punctuated equilibrium better characterizes evolutionary history than does gradualism—change over the geologic long haul cannot be properly understood as simply the steady accumulation of

small changes happening during the typical period. This insight suggests that we cannot readily predict future conditions via the smooth extrapolation of current trends. In particular, if the world is shaped by occasional contingent events that have dramatic consequences—such as asteroid impacts, massive floods from glacial lakes—then history cannot be understood as a march of progress along a mandated path. Many paths exist, and the one that is actually trod upon is not inevitable, but rather determined by the often unpredictable events that actually occur and the historical-structural constraints that exist in tension. Every historical moment contains possibilities, and the future is not predetermined. (The recognition of the importance of contingency is a central aspect of Gould's thinking that we take up in greater depth in chapter 3.)

Throughout his career, Gould worked to show that the widespread assumption in the natural sciences that natural history unfolds in a predictable, progressive, and gradual manner is not necessarily a reflection of the factual processes of the natural world. Rather, it is in part the product of social history, and to some degree reflects the ruling elite's preference for the view that the present state of the world is the inevitable outcome of natural forces and that change is unlikely to come abruptly. Social biases often distort our view of the world, and scientists, even those as great as Darwin and Lyell, are not free from their sway. Gould, drawing on the Marxian tradition, helps us to open our eyes to the possibility that the world as it is did not have to be so and that the future remains open.

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1. See George Gaylord Simpson, *Tempo and Mode in Evolution* (New York: Columbia University Press, 1944).
2. Stephen Jay Gould and Niles Eldredge, "Punctuated Equilibria: The Tempo and Mode of Evolution Reconsidered," *Paleobiology* 3/2 (1977): 115-51. Quotes in this and the subsequent paragraph are from p. 145.
3. Originally, the theory was named "punctuated equilibria," but subsequently became commonly referred to as "punctuated equilibrium," including by Gould. Thus we refer to the theory as punctuated equilibrium throughout this book.
4. Stephen Jay Gould, "Is Uniformitarianism Necessary?" *American Journal of Science* 263 (1965): 223-28.
5. Stephen Jay Gould, *Ever Since Darwin* (New York: W. W. Norton, 1977), 147-52. Subsequent quotes from p. 151. Charles Lyell, *Principles of Geology* (Chicago: University of Chicago Press, 1990). In addition to sources directly referenced in the text, our discussion of uniformitarianism draws upon Gould's essay "Lyell's Pillars of Wisdom" in his book *The Lying Stones of Marrakech* (New York: Harmony Books, 2000). For contemporary adherents to gradualism and the view that history unfolds in a slow and orderly manner, see Daniel Dennett, *Darwin's Dangerous Idea* (New York: Simon & Schuster, 1995); Richard Dawkins, *The Ancestor's Tale* (Boston: Houghton Mifflin, 2004); and Simon Conway Morris, *The Crucible of Creation* (New York: Oxford University Press, 1998) and *Life's Solution* (New York: Cambridge University Press, 2003). For an analysis of the causes of mass extinctions, including a presentation of the evidence indicating that the Cretaceous extinction was caused by the collision of a comet with Earth, see David M. Raup, *Extinction* (New York: W. W. Norton, 1991).
6. Janet Browne, *Charles Darwin: Voyaging* (Princeton: Princeton University Press, 1995); Adrian Desmond and James Moore, *Darwin* (New York: W. W. Norton, 1991).
7. The Cretaceous-Tertiary boundary is now often referred to as the Cretaceous-Paleogene boundary due to the division of the Tertiary Period into the Paleogene and the Neogene by the International Commission on Stratigraphy.
8. Gould, *Ever Since Darwin*; Gould, *The Lying Stones*; Raup, *Extinction*.
9. Karl Marx, *Grundrisse: Foundations of the Critique of Political Economy* (New York: Penguin Books, 1993); and *Economic and Philosophic Manuscripts of 1844* (New York: International Publishers, 1964).
10. Stephen Jay Gould, *The Panda's Thumb* (New York: W. W. Norton, 2000), 196-97.

11. See Niles Eldredge, “The Allopatric Model and Phylogeny in Paleozoic Invertebrates,” *Evolution* 25/1 (1971): 156–67; Niles Eldredge and Stephen Jay Gould, “Punctuated Equilibria: An Alternative to Phyletic Gradualism,” in *Models in Paleobiology*, ed. Thomas J. M. Schopf (San Francisco: Freeman, Cooper, 1972), 82–115; Gould and Eldredge, “Punctuated Equilibria.”
12. Stephen Jay Gould, *The Structure of Evolutionary History* (Cambridge, Mass.: Belknap Press of Harvard University Press, 2002).