

The Exemplary Kuhnian: Gould's *Structure* Revisited

BY GREGORY RADICK*

STEPHEN JAY GOULD. *The Structure of Evolutionary Theory*. Cambridge, MA: Belknap Press, 2002. xxiv + 1433 pp., illus., index. ISBN: 0-674-00613-5. \$39.95 (hardcover).

The *Origin of Species* recognized no goal set either by God or nature. . . . Even such marvelously adapted organs as the eye and hand of man—organs whose design had previously provided powerful arguments for the existence of a supreme artificer and an advance plan—were products of a process that moved steadily *from* primitive beginnings but *toward* no goal.

Thomas S. Kuhn, *The Structure of Scientific Revolutions* (1962)¹

Darwin reveled in this unusual feature of his theory—this mechanism for immediate fit alone, with no rationale for increments of general progress or complexification. . . . The vaunted progress of life is really *random motion away from simple beginnings*, not *directed impetus toward inherently advantageous complexity*.

Stephen Jay Gould, *Life's Grandeur* (1996)²

The echo in Stephen Jay Gould's way of expressing the contrast between goal-directed progress and Darwinian progress—for Thomas Kuhn, the very model of scientific advance—may or may not have been deliberate. Certainly Gould was candid about his debt to *The Structure of Scientific Revolutions*

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The following abbreviations are used: *SET*, Stephen Jay Gould, *The Structure of Evolutionary Theory*; *SSR*, Thomas S. Kuhn, *The Structure of Scientific Revolutions*.

1. Thomas S. Kuhn, *The Structure of Scientific Revolutions*, 2nd ed. (Chicago: University of Chicago Press, 1970), 172; emphases in original, passage unchanged from 1962 edition.

2. Stephen Jay Gould, *Life's Grandeur: The Spread of Excellence from Plato to Darwin* (London: Jonathan Cape, 1996), 140, 173. The book was published in the United States under the title *Full House*.

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(*SSR*). He even recorded the circumstances that led him to it not long after its publication. In 1963, a friend at Columbia University named Mike Ross, a graduate student in sociology of science under the field's presiding figure, Robert Merton, told Gould excitedly (the quotation marks are his): "you just have to read this book right away." Gould was then beginning his own graduate studies at Columbia, in invertebrate paleontology. The recollection continues: "I usually ignore such breathless admonitions, but I respected Mike's judgment, and I'm surely glad that I followed his advice. In fact, I went right to the bookstore and bought a copy of Kuhn's slim volume" (967). A half century after its appearance, Kuhn's volume is at the top of the agenda for anniversary-minded people in history, philosophy, and sociology of science. But anyone wishing to gauge its significance would do well to reflect on Gould's life and work, above all the flawed masterpiece where he set down his reminiscence, under a title with a Kuhnian ring, *The Structure of Evolutionary Theory* (*SET*). Published in 2002, it is enjoying a modest anniversary of its own this year—reason enough for a look back at a book more often bought than read and, if opened, more skimmed than studied. The theme of Gould as Kuhnian can serve as a useful as well as a timely point of entry into a complex work that is quite a lot better, and also quite a lot stranger, than tends to be recognized.

That Kuhnifying scene occurs near the end of a chapter—at 279 pages, the longest chapter in a very long book—expounding and defending the theory of punctuated equilibrium.³ In the 1970s, the theory was reputation-making for Gould; in *SET*, his last major professional contribution, it stands as the synthetic climax of two hundred years of debate and discovery, lovingly chronicled.⁴ Bringing to a close a survey of punctuational models in disciplines beyond his own, he turned to the history of ideas, including the question of how much his own initial enthusiasm for punctuated evolutionary change might have owed to his prior enthusiasm for *SSR*. His answer was: a lot. Asked "to cite any one factor as probably most important among the

3. That chapter has since been published as a separate volume: Stephen Jay Gould, *Punctuated Equilibrium* (Cambridge, MA: Harvard University Press, 2007).

4. The key papers of the 1970s are Niles Eldredge and Stephen Jay Gould, "Punctuated Equilibria: An Alternative to Phyletic Gradualism," in *Models in Paleobiology*, ed. T. J. M. Schopf (San Francisco: Freeman, Cooper & Co., 1972), 82–115, and Stephen Jay Gould and Niles Eldredge, "Punctuated Equilibria: The Tempo and Mode of Evolution Reconsidered," *Paleobiology* 3, no. 2 (1977): 115–51. Many of Gould's essays and papers, including these two, are available at www.stephenjaygould.org.

numerous influences that predisposed my own mind toward joining [fellow paleontologist] Niles Eldredge in the formulation of punctuated equilibrium,” he would give *SSR* pride of place (967). Persuaded by Kuhn’s picture of scientific change as a discontinuous process, characterized by periods of stable “normal science” separated by brief but convulsive “paradigm shifts,” Gould was, by his own reckoning, all the readier to accept a picture of speciation as happening most often in relatively short bursts after long periods of comparative stasis. He denied taking the word “punctuated” from Kuhn, who used it only in the postscript to the second, 1970 edition of *SSR*, which Gould (not implausibly) claimed to read only after he and Eldredge had devised and presented their theory, first at a conference in 1971 and then in print in 1972. But Gould betrayed no anxiety even at the counterfactual thought of having done so. The word, like the view of history it named, was just in the air. In Gould’s view, Kuhn’s theory was an early (and especially brilliant) expression in one domain, and the Eldredge-Gould theory a later expression in another domain, of a wider development that should be understood as a “punctuational paradigm about the nature of change—a worldview that may, among scholars of the new millennium, be judged as a distinctive and important movement within the intellectual history of the later 20th century” (970).

Exposing the cultural roots of scientific work, his own as much as anyone else’s, was for Gould, as for Kuhn, simply a part of the enterprise of understanding science and therefore of understanding nature. In no way did such rootedness undermine the objectivity of the work or the genuineness of the understanding. Those who share these sentiments will likely share Gould’s frustration, explicit in *SET*, over the way his scientific critics pounced on his conjecturing about the influence on his science of the Marxism he learned as a child (from his leftist father in postwar Queens). He quoted at length from a letter he published in 1981 in *Nature* urging a more symmetrical view of such matters:

I did not develop the theory of punctuated equilibrium as part of a sinister plot to foment world revolution, but rather as an attempt to resolve the oldest empirical dilemma impeding an integration of paleontology into modern evolutionary thought: the phenomena of stasis within successful fossil species, and abrupt replacement by descendants. I did briefly discuss the congeniality of punctuational change and Marxist thought ... but only to illustrate that all science, as historians know so well and scientists hate to admit, is socially

embedded. I couldn't very well charge that gradualists reflected the politics of their time and then claim that I had discovered unsullied truth (985).⁵

There is a further sense in which Gould's achievement, in *SET* and more generally, follows on from *SSR* and from a number of other meta-scientific works of the era. He touched on the point obliquely in a footnote to the discussion of Kuhn in *SET*. If science really is as much like the arts as Kuhn suggested, with both lending themselves to periodization by style traditions broken up by revolutions, why does science progress as the arts do not? It must be, Gould supposed, because, unlike in the arts, in science there is a "there" out there to be right or wrong about. But he immediately qualified "this fluffy claim of such charming naivete." "After all," he went on, "we only 'see' through our minds (not to mention our social organizations and their pervasive biases)" (969). Nothing was more of the Kuhnian moment—and more broadly, of the post-positivism of which Kuhn's book was the most enduring statement—than the willingness, in discussing science, to put "see" in quotation marks. Contrary to supposed positivist teachings, observations were "theory laden" (Norwood Hanson's famous phrase). Theories, taken in the most expansive sense to encompass even unconscious "biases," were where the analytical action lay for the student of science, even for those, like Karl Popper, who were largely unsympathetic to Kuhn's project.⁶

It was to Kuhn that Gould ascribed his own introduction to post-positivist possibilities. In a 1995 interview, he credited *SSR* with releasing him from the grip of the "inductivist, ameliorative, progressive, add-a-fact-at-a-time-don't-theorize-till-you're-old model of doing science."⁷ That would not have been immediately apparent to readers of the debut paper on punctuated equilibrium, where Kuhn received only a rather offhand mention in a footnote. But the post-positivism was right up front. "The Cloven Hoofprint of Theory" was the title of the first subsection, about how gradualist presuppositions had gone so deep among paleontologists that nothing found in the fossil record could ever make them doubt gradualist theory. Only the

5. See also pp. 1017–19 and, for the letter, Stephen Jay Gould, "Museum Debate," *Nature* 289 (26 Feb 1981): 742.

6. On post-positivism, see John H. Zammito, *A Nice Derangement of Epistemes: Post-Positivism in the Study of Science from Quine to Latour* (Chicago: University of Chicago Press, 2004), esp. ch. 1. On "seeing as a 'theory-laden' undertaking," see N. R. Hanson, *Patterns of Discovery: An Inquiry into the Conceptual Foundations of Science* (Cambridge: Cambridge University Press, 1958), 19.

7. John Horgan, "Profile: Stephen Jay Gould: Escaping in a Cloud of Ink," *Scientific American* 273 (August 1995): 26–27.

development of a nongradualist alternative could transform gradualism from an untestable background assumption into a testable proposition. In arguing the case, Gould—who, as David Sepkoski has now established, added this subsection (and much else) to Eldredge’s original manuscript—surveyed the recent shift among philosophers and psychologists away from an “inductivist credo” that now seemed “naive and untenable.” He cited Hanson, as well as Paul Feyerabend and the Popperian immunologist Peter Medawar, whose declaration that “Innocent, unbiased observation is a myth” furnished an epigram. (The line, incidentally, came from Medawar’s *Induction and Intuition in Scientific Thought* (1969), from which, in a similar spirit, Gould also quoted what became his favorite bit of Darwin, from an 1861 letter: “How odd it is that anyone should not see that all observation must be for or against some view if it is to be of any service.”)⁸

We read and hear often enough nowadays that post-positivism, with its own, theory-privileging biases, is passing or indeed has passed. Lab and field practices, scientific communication, positivism itself (so much richer than the caricature): these topics and more at last receive their share of attention.⁹ It is easy, when post-positivism has come to be seen as something inhibitive, to forget how liberating it once seemed. Gould’s immensely creative oeuvre is a corrective. It also testifies to the power of the emphasis on theory to make even technically challenging science accessible and exciting. His best-known popular books—*The Mismeasure of Man* (1981), on the research behind claims of racial hierarchy in intelligence, and *Wonderful Life* (1989), on the interpretation and reinterpretation of Cambrian fossils in the Burgess Shale in Canada—are bravura explorations of bias at work in the transit from observations to conclusions.¹⁰ So too are a great many of the three hundred essays that he published monthly, from 1974 to 2001, in *Natural History* magazine.¹¹

8. Eldredge and Gould, “Punctuated Equilibria” (ref. 4), 84–86; David Sepkoski, *Rereading the Fossil Record: The Growth of Paleobiology as an Evolutionary Discipline* (Chicago: University of Chicago Press, 2012), 166–70 (cf. Gould, *SET*, 775); Peter Medawar, *Induction and Intuition in Scientific Thought* (London: Methuen & Co., 1969), 28, on 11 for the Darwin quotation (from a letter to Henry Fawcett, 18 Sep 1861).

9. See, e.g., Peter Galison, “Ten Problems in History and Philosophy of Science,” *Isis* 99 (2008): 111–24, on 111; David Wootton, “Traffic of the Mind,” *Times Literary Supplement* 5664 (21 Oct 2011): 3–5, on 4.

10. Stephen Jay Gould, *The Mismeasure of Man* (London: Penguin, 1981; revised and expanded edition, 1996); Stephen Jay Gould, *Wonderful Life: The Burgess Shale and the Nature of History* (London: Hutchinson Radius, 1989).

11. On one count, the theme of “theory-data” is central to 143 out of the 300; see Michael B. Shermer, “This View of Science: Stephen Jay Gould as Historian of Science and Scientific

Those amazing essays deserve a retrospective unto themselves. But for present purposes, it will suffice to consider just one: the title essay in his collection *Dinosaur in a Haystack* (1996). It is about then-recent attempts to search the rocks near the Cretaceous-Tertiary boundary comprehensively—inch by inch, with unprecedented thoroughness—for the presence of the ammonite and dinosaur fossils which might show that these groups went extinct not gradually and at different rates but suddenly and at the same time. Thematically the essay is a return to the theory/observation material of the 1972 punctuated equilibrium paper, down to the Popperish quotation from Darwin. But empirically it offers a thorough updating which in turn refreshes the theme. These search efforts were undertaken, Gould stressed, only because of the arrival in 1979 of a new theory which made it worthwhile to make them. The theory posited the wipeout of the dinosaurs in a mass extinction triggered by the impact of an extraterrestrial body of some kind. Ammonite expert Peter Ward was confident that no fossils would be found near the boundary, and would never have bothered looking if not provoked by this theory, whose prediction he expected to falsify. But there they were.¹² Equally intriguing—and equally serviceable in making concrete the abstract lesson about how impotent mere data are in the face of a gradualist geological consensus—is the coverage of the “Signor-Lipps effect.” From the early 1980s it was understood that the use of standard sampling methods in paleontology would tend to deliver data sets seemingly showing gradual, differently paced extinctions even when extinctions had actually occurred suddenly and simultaneously, simply because some species are rarer than others, and the fossils of rarer species are less likely to be found in the more recent strata. Gould concluded the essay with a *Wonderful Life*-vintage flourish: what really hangs in the balance in this debate over dinosaurs and ammonites and paleontological methods is our image of ourselves, as cosmically predestined, or as the contingent products of a mammalian lineage that might never have amounted to much had the dinosaurs not been forcibly dislodged.¹³

Historian, Popular Scientist and Scientific Popularizer,” *Social Studies of Science* 32, no. 4 (2002): 489–524, 508–09.

12. And therein, for Gould, lay objectivity: not in the absence of expectations and preferences, but in the willingness to admit when the world fails to conform to them. Symmetrical as ever, Gould cheerfully reflected that his own early and, in his view, subsequently vindicated support for the extraterrestrial-impact theory followed from its good fit with punctuated equilibrium theory; Gould, *SET*, 1307–08.

13. Stephen Jay Gould, “Dinosaur in a Haystack,” in his *Dinosaur in a Haystack: Reflections in Natural History* (London: Jonathan Cape), ch. 12. Gould published ten such collections,

The same collection includes a superb essay on metaphor in Darwin's writings and in those of his grandfather Erasmus, with much insightful probing of why, for many readers, Charles's imagery works so much more effectively than Erasmus's.¹⁴ Unfortunately the lesson Gould drew there, on the need for a tight match between imagery and argument, with the former strictly subservient to the latter, went unheeded in the writing of *SET*. Let me set aside for the moment Gould's choice of imagery for his argument in *SET* and consider just the argument, which is highly original and interesting. A helpful way in is via another bit of 1960s philosophy of science: the notion that scientific theories yield testable predictions only with supplementation from "auxiliary assumptions," in the terminology of Carl Hempel, the most Kuhn-friendly of the positivists (Kuhn returned the compliment).¹⁵ Gould's thesis in *SET* is that the theory of natural selection gets the needed boost from auxiliary assumptions on three topics, as Darwinians seeking to connect their theory to the world make three sorts of decisions.

One concerns the level or levels of biological organization where natural selection operates, and therefore the entities it operates upon. From Darwin's day, the selected entity *par excellence* has been the individual organism. But candidate entities have long since proliferated, down to DNA nucleotides and up to species. Gould's inapt label for this genre of auxiliary assumption is "agency" (the selected entities are not, after all, the agents of the action but its objects). A second decision concerns what Gould called "efficacy," to do with how lightly or heavily constrained natural variability is, and therefore how much or how little room for maneuver natural selection has in adapting lineages to changing environments. As internal constraints on anatomical possibility decrease, the prospects for gradual, cumulative, environment-tracking change increase. A third decision, about "scope," concerns the environments themselves. Assume that constancy and orderliness characterize environmental change, and you will confidently credit natural selection with having determined much about the present biological order, since those are the conditions that allow natural selection to accumulate adaptive change unimpeded. Assume, however, that such steady building up of adaptive change has been

starting with Stephen Jay Gould, *Ever Since Darwin: Reflections in Natural History* (New York: W. W. Norton and Company, 1977).

14. Stephen Jay Gould, "Four Metaphors in Three Generations," in Gould, *Dinosaur* (ref. 13), ch. 34.

15. Carl G. Hempel, *Philosophy of Natural Science* (Englewood Cliffs, NJ: Prentice-Hall, 1966), 23; on Hempel and Kuhn, see Zammito, *Nice Derangement of Epistemes* (ref. 6), 9.

occasionally and unpredictably upended—as when, say, something large smacked into the Yucatán at the end of the Cretaceous, making the world suddenly deadly for dinosaurs and ammonites but not for mammals—and you will be much less confident in assigning responsibility to natural selection.

All of Gould's labels are terrible. Each of the three kinds of auxiliary assumption might legitimately be said to bear on the "scope" of natural selection, or its "efficacy." Never mind. His three-auxiliaries thesis—so economical in binding together a range of big issues, and so obviously the product of profound conceptual engagement with Darwinian theory—can easily enough be comprehended without them. And surely better labels could be invented. I recommend "for/against entity hierarchy," "for/against internal constraint," and "for/against external constraint," which at least are not blandly interchangeable or grossly misleading, and which also have the virtue of representing the dichotomous nature of the decisions involved. In Gould's view, if you are for entity hierarchy, you are a good bet to be for internal and external constraints; and if you are against any of those, you are a good bet to be against all of them.

Now we come to that strangeness I mentioned at the outset. In the following passage, which appears in the middle of a sensitive and illuminating discussion of Goethe's morphology, Gould explains why the bets line up as they do:

We should, I believe, recognize the space of our intellectual world as inherently structured, by some combination of our evolved mental quirks and the dictates of logic, into a discontinuous array of possible, coherent positions—hence the *double entendre* in the title of this book. These mental positions express "morphologies," just as organisms do. The chief components of these "morphologies" must reside together and interact to build the "essence" of any powerful intellectual system. The components of a theory's essence should be recognized as both deep and minimal; with other less important and potentially dispensable principles allied to them in secondary webs subject to "restructuring" by "adaptation." (Thus I advocate a minimal set of three principles [the auxiliary assumptions] for defining the essence of Darwinism, while regarding other components of the usual Darwinian nexus as conjoined more loosely and less central intellectually.) These essential and minimal components remain correlated, although arising independently and in reiterated fashion, across languages, centuries and cultural traditions. Such firm linkages define the structure of these few nucleating positions in the intellectual landscape (290).

The position, I take it, is that biological theorists of whatever place and period who find themselves deciding one way on an auxiliary question will eventually

find themselves fully on one or the other side of the three-auxiliaries dichotomy. If they decide that, say, internal constraints, of the sort captured in morphologists' talk of "laws of form," do not matter all that much in explaining why a plant or an animal is as it is, then they will eventually insist that selection operates at just one level, and furthermore that environmental change can be presumed to be uniformly gradual. The one decision entails the others, and anyone starting with any of the same-side decisions on the other two auxiliary questions would likewise end up with the same package of decisions, adding up to an overall perspective on organisms as extremely well adapted to environments. Over at the other pole, theorists who decide that laws of form do matter a great deal will go on to embrace entity hierarchy and the importance of external constraints such as asteroid collisions, as part and parcel of the anti-adaptationism lurking within the initial decision. In short: Dawkins versus Gould. (Dawkins in fact comes in for a mighty drubbing in the book (615–41).)¹⁶

What is so strange here? For longstanding Gould readers, three things stand out. First, there is the idea that the theory of natural selection plus the three auxiliary assumptions fix a timeless, culture-transcending "essence of Darwinism." If ever there was a naturalist who embraced anti-essentialism as *the* great Darwinian teaching, it was Gould. The big historical story for him was "the spread of excellence from Plato to Darwin" (to quote the subtitle of his book on evolutionary progress), in the course of which humankind came to see variable individuals and not abstract types as what was really real. Gould held essentialism to be dangerously false, a philosophical prop for the worst racist and sexist abuses. Yet he stressed in *SET* that an essentialist view was the right one to take about scientific theories. Not just any evolutionary theory could count as a Darwinian theory; and what made a theory Darwinian was not just a matter of convention and consensus.¹⁷ Second, we see his enthusiasm for the use of biological concepts and language to describe and, maybe, explain why the history of scientific theorizing in biology has the shape it does. One would have imagined someone with Gould's history of opposing sociobiology and evolutionary psychology to take a dim view of any such evolutionary epistemology. But in *SET*, he embraced it, to the point of stressing that he intended readers

16. On Gould's disagreements with Dawkins more generally, see Kim Sterelny, *Dawkins vs. Gould: Survival of the Fittest* (Cambridge: Icon, 2001).

17. He defended theory essentialism at greatest length on pp. 1–12; see also p. 41 on his realizing that "a 'Platonic' something 'up there' in ideological space could coordinate all these critiques and fascinations into a revised general theory with a retained Darwinian base."

to associate the book's title with the anti-adaptationist, structuralist morphologizing of Goethe, Geoffroy, Owen, Agassiz, and the rest.¹⁸ Third, there is that remark about how the dichotomous structuring of ideas about organisms arises from "some combination of our evolved mental quirks and the dictates of logic." Again, one expects Gould to have nothing but contempt for evolutionary psychology. But near the end of his life—he died in 2002, aged 60, poignantly soon after *SET* was published—he began to speculate in print about how the human tendency to dichotomize was a legacy from nonhuman ancestors whose lives, or deaths, depended on fight-or-flight calculations made within simple brains (598n).¹⁹ Darwinian evolutionary theory clumps into two groupings, then, in part because of affinities among the available auxiliary assumptions (logic) and in part because our evolved minds tend automatically toward two-way clumpings (psychology). Logic and psychology: one could do worse at summarizing what Kuhn, with his vision of normal science as puzzle-solving and revolutionary science as Gestalt switches, brought together so dramatically.

Given this extraordinary set of proposals, and the role they play in organizing Gould's massive text, it is the more unfortunate that he chose to represent them visually by a three-branched fossil coral. He found the image in an early-modern book of natural history; we find it on the cover of *SET* and printed twice within, where, in one of the captions, Gould declared that, "fortuitously (and without any alteration whatsoever), [it] presents a detailed picture of the basic logic of Darwinian theory as recognized in this book" (18). It does no such thing. Yes, Gould believed that there are three kinds of auxiliary assumption needed before the theory of natural selection becomes a fully functional evolutionary theory. But those assumptions do not lend themselves at all well to glossing as separate branchings from a selectional trunk. For one thing, the assumptions involve topics that, although relevant for the interpretation of selection theory, are themselves external to it—quite the opposite of the descent relationships which branching trees ordinarily symbolize, above all in Darwinian theory. For another, the branches in the fossil coral neither coordinate nor terminate; and to that extent, there is no straightforward way to read into the

18. Not only do theories have essences but so, "in a more restrictive and nuanced sense, do organisms—in their limitation and channeling by constraints of structure and history" (10). And further down the same page: "the solution to a meaningful notion of essence in biology lies . . . with Goethe, Etienne Geoffroy St. Hilaire, and Richard Owen."

19. See also Stephen Jay Gould, *The Hedgehog, The Fox, and the Magister's Pox: Mending the Gap Between Science and the Humanities* (New York: Harmony, 2003), 82–83.

image, or read out of it, a mapping of Gould's notion that decisions made on each of the three auxiliary topics function together in order to complete selection theory. And, most obviously, nothing in the three-branched image conveys a hint of the structural bifurcation that Gould thought so important to understanding why evolutionary theorizing, and the long run of debate around it, has taken the forms it has.²⁰

Notwithstanding Gould's misguided attempt to provide a visual aid for his three-auxiliaries thesis, once one understands the thesis, *SET* discloses itself as what Gould (now echoing Darwin) boasted it to be: "one long argument." A constant refrain in the reviews was that the book was too long, suffering from bloat brought on by the digressive self-indulgence which, in the eyes of many, disfigured Gould's late-period writing.²¹ Unquestionably *SET* is not a book to be read quickly, as of course the reviewers had to do. Another source of reviewer irritation may have been over-familiarity. They had simply had enough of Gould, and resented having to read, yet again, about punctuated equilibrium and all its outriders—species selection, spandrels and exaptations, contingency and randomness—however novel Gould considered the book's presentation and integration of them. Ten years on, it is easier to see both that Gould was writing not for past readers but for future ones, and that, however expansive his treatment of what might seem tangential matters (four pages on Kuhn will surely have tried the patience of some scientific readers), everything takes its place within a chapter scheme aligned more or less tightly with the thesis being argued for.

To show the correctness of his diagnosis of evolutionary theory's logical structure—with its trio of auxiliary decisions and pair of decision clusterings, adaptationist and structuralist—Gould offered a comprehensive reconstruction of the relevant history of science as conforming to that structure. Overall, it is a history of debate within and around a sequence of three resting points. The first was Darwin's own evolutionary theorizing (ch. 2). The second was the neo-Darwinian modern synthesis of the mid-twentieth century (ch. 7). Before and between these two moments of adaptationist clustering there developed, in Gould's version, traditions of structuralist dissent, on entity hierarchy (ch. 3), internal constraints (chs. 4 and 5), and external constraints (ch. 6). The modern synthesis satisfied for a while, but the dissenting traditions picked up

20. Here I have ignored Gould's convoluted interpretation of segmental "cuts" on the trunk and branches; it only makes things worse.

21. See, e.g., David Quammen, "The Man Who Knew Too Much: Stephen Jay Gould's Opus Posthumous," *Harper's Magazine* (1 Jun 2002): 73–80, available at www.stephenjaygould.org.

momentum in the later twentieth century, in all three areas: entity hierarchy (ch. 8), internal constraints (chs. 10 and 11), and external constraints (ch. 12). The third resting point, inevitably provisional, is the theory of punctuated equilibrium (ch. 9, but spiritually the last chapter). That theory for Gould seemed to be both a triumph of the structuralist clustering and, insofar as selection theory remained firmly at the core, a synthesis of adaptationism and structuralism.²²

The upshot is a structure that, whatever one makes of the Platonic spin Gould gave to it, and whatever one's attitude to adaptationism, provided Gould with ample opportunity for the detailed *explication de texte* of which he was master. I mentioned the discussion of Goethe, but he is but one of a very large cast of biological thinkers whose writings receive thoughtful commentary. The one who commands the most pages by far, even into the later chapters, is Charles Darwin. *SET* offers some of the most suggestive and sustained exegeses of Darwin's letters and books, above all the *Origin of Species*, now available. Consider, for example, Gould's analysis of Darwin as a historical reasoner. What, in general, is there to say about *how* Darwin reasoned backward from what he and others saw around them? There was, of course, extrapolation from the present to the past, under the Lyellian assumption that past causes are uniform with presently acting ones. But there were, on Gould's count, three other methods: "sequencing" (ordering of present phenomena as steps in a historical sequence); "consilience" (bringing together disparate facts which are all well explained if the past was a certain way and impossible to explain otherwise); and "discordance" (identification of the imperfections, oddities, mismatches that are the signatures of historical processes). Gould nominated a different book of Darwin's as emblem for the different methods—the earthworm book for extrapolation, the book on coral reefs for sequencing, and so on—before showing how the *Origin* made extensive use of each. Like the best history of this kind, Gould's schema helps the reader step back from the texts and, in so doing, helps to bring the texts closer (103–16).²³

22. Do not take too seriously Gould's own grouping of the chapters, following a first introductory chapter, into a historical part (chs. 2–7) and a scientific part (chs. 8–12), on the model of his other technically focused book, Stephen Jay Gould, *Ontogeny and Phylogeny* (Cambridge, MA: Belknap Press, 1977). The historical part is only loosely chronological, and the scientific part is shot through with history.

23. For consilience, Gould selected Darwin's 1877 book on the forms of flowers; for discordance, his 1862 book on orchids.

Other things that Gould had to say about Darwin are more plainly tied to the thesis of *SET*, with mixed results. There is a virtuoso rereading of Darwin on the “principle of divergence,” and a persuasive suggestion that the awkwardness in Darwin’s writing about it stemmed from an inability to reconcile his commitment to explanation at the level of the organism with his understanding that, if he was going to explain that principle, the explanation would have to involve a level above the organism (135–36, 224–50). But there is also a rerun of the mischievous account of Darwin on progress from the 1996 book whose Kuhnian phrasing I quoted at the start. In brief, Gould held that Darwin appreciated, and acknowledged in private, that natural selection cannot in itself bring about evolutionary progress, since selection only follows where environments lead, and these will sometimes favor greater complexity and sometimes not. Since he could not bear to undermine Victorian optimism with that depressing news, however, he found a way in the *Origin* to get progress out of organism-level selection by supposing, first of all, that organism-to-organism competition was what mattered (more than physical surroundings), and second, that the world got gradually more crowded with ever more numerous, ever more competitive organisms (with none of the occasional emptyings out that follow from, say, asteroid collisions) (467–79).

Such a blending of text and context would, if sound, go a long way toward explaining why Darwin decided against external constraints in his evolutionary theorizing. In Gould’s words from *SET*, “By this ingenious strategy, Darwin managed to have his cake of unified theory at a single, accessible level, and also to satisfy his culture’s hunger for rationalizing progress” (479). But the truly ingenious strategy here was Gould’s. A much more straightforward reading of the relevant passages in the *Origin* and elsewhere is that, publicly and privately, Darwin believed that natural selection favored greater complexity other things being equal, with the result that, over geological time, the complexity of the most complexly organized species gradually increased. This Darwinian tendency to progress was, like the Newtonian tendency of moving bodies to travel in a straight line at constant speed forever, or the Malthusian tendency of populations to increase geometrically, manifest unless somehow obstructed—which of course it could be. For Darwin, then, selection could be progressive whether or not environments permit it to be progressive. For Gould, by contrast, selection could be progressive only if environments permit it to be so, at least more often than not. Where Darwin’s approach was that of a thinker taught to think in Newtonian terms, Gould’s approach was in terms of the statistics in which he had been trained (and which did not exist in 1859).

Projecting his own sense of the problem backward onto Darwin, Gould supposed that, if Darwin proclaimed selection to be progressive, then somewhere in the *Origin* there must be a mechanism to ensure that greater complexity beats lower complexity more often than not. And Gould found such a mechanism, albeit only by putting together ideas that Darwin himself never put together in that way.²⁴

Readers of *SET* are on their mettle, then. But of how many books of history of science by working scientists can that be said? And has anyone ever taken more fully to heart that famous first line of *SSR*: “History, if viewed as a repository for more than anecdote or chronology, could produce a decisive transformation in the image of science by which we are now possessed”?²⁵ From his very first publication in 1965, calling on geologists to drop the word “uniformitarianism” as an unhelpful survival into an era when the doctrines it named had been falsified or marginalized, Gould took critical inquiry into the history of his science to be part of the job description.²⁶ The theory of punctuated equilibrium that soon followed may never have yielded up a Kuhnian exemplar (to use Kuhn’s own preferred paraphrase for “paradigm”). But there are other kinds of success in science.²⁷ And in his fascination with the theory-observation relationship, in all its dimensions and permutations, and in his often if not always successful attempts to engage the scientific past without imposing present categories (the two go together), Gould was an exemplary Kuhnian—which should make him, in more ways than one, an instructive figure. At the end of

24. For a fuller version of this critique, see Gregory Radick, “Two Explanations of Evolutionary Progress,” *Biology and Philosophy* 15, no. 4 (2000): 475–91. Darwin’s devotion to gradualist geology was of course inherited from Lyell, who, however, linked it to a *denial* of biological progress.

25. Kuhn, *SSR* (ref. 1), 1.

26. Stephen Jay Gould, “Is Uniformitarianism Necessary?” *American Journal of Science* 263 (1965): 223–28. Not that Kuhn’s lessons had been fully absorbed; one of Gould’s arguments for jettisoning the word was that, in its methodological sense, “uniformitarian” just meant “inductive,” and that just meant “scientific,” so to say that geology was uniformitarian was merely to insist on what everyone rightly took for granted anyway.

27. On punctuated equilibrium theory as failing to attract followers for reasons that a Kuhnian perspective illuminates, see Michael Ruse, *Mystery of Mysteries: Is Evolution a Social Construction?* (Cambridge, MA: Harvard University Press, 1999), 149–52. Three books that together enable a more rounded view of Gould’s achievement have recently been published: Warren D. Allmon, Patricia H. Kelley, and Robert M. Ross, eds., *Stephen Jay Gould: Reflections on His View of Life* (Oxford: Oxford University Press, 2009, and with a comprehensive Gould bibliography); David F. Prindle, *Stephen Jay Gould and the Politics of Evolution* (Amherst, NY: Prometheus Books, 2009); Richard York and Brett Clark, *The Science and Humanism of Stephen Jay Gould* (New York: Monthly Review Press, 2011).

the introduction to *SET*, Gould put himself forward: “Please read the book!” (89).²⁸ Ten years later, if you have not done so already, you might take him up on it.

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28. Gould had ended the first chapter of *Ontogeny and Phylogeny* (ref. 22) with the same plea.

