CHAPTER TEN

Bully for Brontosaurus

1. THE BOY WHO CRIED WOLF?

Scientists have power by virtue of the respect commanded by the discipline. We may therefore be sorely tempted to misuse that power in furthering a personal prejudice or social goal—why not provide that extra oomph by extending the umbrella of science over a personal preference in ethics or politics? But we cannot, lest we lose the very respect that tempted us in the first place.

—STEPHEN JAY GOULD 1991b, pp. 429-30

Many years ago, I saw a program on British television in which young children were interviewed about Queen Elizabeth II. Their confident answers were charming: the Queen, it seems, spends a large part of the day vacuum-cleaning Buckingham Palace—while wearing her crown, of course. She pulls the throne up to the telly when she is not occupied with affairs of state, and wears an apron over her ermine robes when she does the washing up. I realized then that the largely imaginary Queen Elizabeth II of these young children (what philosophers would call their intentional object) was in some regards a more potent and interesting object in the world than the actual woman. Intentional objects are the creatures of beliefs, and hence they play a more direct role in guiding (or misguiding) people’s behavior than do the real objects they purport to be identical to. The gold in Fort Knox, for example, is less important than what is believed about it, and the Albert Einstein of myth is, like Santa Claus, much better known than the relatively dimly remembered historical fellow who was the primary source for the myth.

This chapter is about another myth—Stephen Jay Gould, Refuter of Orthodox Darwinism. Over the years, Gould has mounted a series of attacks on aspects of contemporary neo-Darwinism, and although none of these attacks has proven to be more than a mild corrective to orthodoxy at best, their rhetorical impact on the outside world has been immense and disturbing. This presents me with a problem that I cannot ignore or postpone. In my own work over the years, I have often appealed to evolutionary considerations, and have almost as often run into a curious current of resistance: my appeals to Darwinian reasoning have been bluntly rejected as discredited, out-of-date science by philosophers, psychologists, linguists, anthropologists, and others who have bluntly informed me that I have got my biology all wrong—I haven’t been doing my homework, because Steve Gould has shown that Darwinism isn’t in such good shape after all. Indeed, it is close to extinction.

That is a myth, but a very influential myth, even in the halls of science. I have tried in this book to present an accurate account of evolutionary thinking, deflecting the reader from common misunderstandings, and defending the theory against ill-grounded objections. I have had a lot of expert help and advice, and so I am confident that I have succeeded. But the view of Darwinian thinking I have presented is quite at odds with the view made familiar to many by Gould. Surely, then, my view must be mistaken? After all, who knows better about Darwin and Darwinism than Gould?

Americans are notoriously ill-informed about evolution. A recent Gallup poll (June 1993) discovered that 47 percent of adult Americans believe that Homo sapiens is a species created by God less than ten thousand years ago. But insofar as they know anything at all about the subject, it is probably due more to Gould than to anyone else. In the battle over the teaching of “creation science” in the schools, he has been a key witness for the defense of evolution in the court cases that continue to plague American education. For twenty years, his monthly column, “This View of Life,” in Natural History, has provided professional and amateur biologists with a steady stream of arresting insights, fascinating facts, and well-needed correctives to their thinking. In addition to his collections of these essays, in such volumes as Ever Since Darwin (1977a), The Panda’s Thumb (1980a), Hen’s Teeth and Horse’s Toes (1983b), The Flamingo’s Smile (1985), Bully for Brontosaurus (1991b), and Eight Little Piggies (1993d), and his technical publications on snails and paleontology, he has written a major theoretical book, Ontogeny and Phylogeny (1977b); an attack on IQ testing, The Mis-measure of Man (1981); a book on the reinterpretation of the fauna of the Burgess Shale, Wonderful Life (1989a); and numerous other articles on topics ranging from Bach to baseball, from the nature of time to the compromises of Jurassic Park. Most of this is simply wonderful: astonishingly erudite, the very model of a scientist who recognizes, as my high-school physics teacher once said, that science, done right, is one of the humanities.

The title of Gould’s monthly column comes from Darwin, the closing sentence of Origin of Species.
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The title of Gould’s monthly column comes from Darwin, the closing sentence of Origin of Species.
There is grandeur in this view of life, with its several powers, having been originally breathed into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed laws of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved.

Anybody as prolific and energetic as Gould would surely have an agenda beyond that of simply educating and delighting his fellow human beings about the Darwinian view of life. In fact, he has had numerous agendas. He has fought hard against prejudice, and particularly against the abuse of scientific research (and scientific prestige) by those who would clothe their political ideologies in the potent mantle of scientific respectability. It is important to recognize that Darwinism has always had an unfortunate power to attract the most unwelcome enthusiasts—demagogues and psychopaths and misanthropes and other abusers of Darwin’s dangerous idea. Gould has laid this sad story bare in dozens of tales, about the Social Darwinists, about unspeakable racists, and most poignantly about basically good people who got confused—seduced and abandoned, you might say—by one Darwinian siren or another. It is all too easy to run off half cocked with some poorly understood version of Darwinian thinking, and Gould has made it a major part of his life’s work to protect his hero from this sort of abuse.

The irony is that his own strenuous efforts to protect Darwinism have sometimes backfired. Gould has been a defender of his own brand of Darwinism, but an ardent opponent of what he has called "ultra-Darwinism" or "hyper-Darwinism." What is the difference? The uncompromising "no-skyhooks-allowed" Darwinism I have presented is, by Gould’s lights, hyper-Darwinism, an extremist view that needs overthrowing. Since in fact it is, as I have said, quite orthodox neo-Darwinism, Gould’s campaigns have had to take the form of calls for revolution. Time and again, Gould has announced from his bully-pulpit to a fascinated world of onlookers that neo-Darwinism is dead, supplanted by a revolutionary new vision—still Darwinian, but overthrowing the establishment view. It hasn't happened. As Simon Conway Morris, one of the heroes of Gould’s Wonderful Life, has said, "His views have done much to stir the established orthodoxies, even if, when the dust settles, the edifice of evolutionary theory still looks little changed" (Conway Morris 1991, p. 6).

Gould is not the only evolutionist to succumb to the urge of overdramatization. Manfred Eigen and Stuart Kauffman—and there are others we haven’t considered—have also styled themselves at first as radical heretics. Who wouldn't prefer one’s contributions to be truly revolutionary? But whereas Eigen and Kauffman, as we have seen, have moderated their rhetoric in due course, Gould has gone from revolution to revolution. So far, his declarations of revolution have all been false alarms, but he has kept on trying, defying the moral of Aesop's fable about the boy who cried wolf. This has earned him not just a credibility problem (among scientists), but also the animosity of some of his colleagues, who have felt the sting of what they consider to be undeserved public condemnation in the face of his influential campaigns. As Robert Wright (1990, p. 30) puts it, Gould is "America’s evolutionist laureate. If he has been systematically misleading Americans about what evolution is and what it means, that amounts to a lot of intellectual damage."

Has he done this? Consider the following. If you believe:

(1) that adaptationism has been refuted or relegated to a minor role in evolutionary biology, or
(2) that since adaptationism is "the central intellectual flaw of sociobiology" (Gould 1993a, p. 319), sociobiology has been utterly discredited as a scientific discipline, or
(3) that Gould and Eldredge’s hypothesis of punctuated equilibrium overthrew orthodox neo-Darwinism, or
(4) that Gould has shown that the fact of mass extinction refutes the "extrapolationism" that is the ‘Achilles’ heel of orthodox neo-Darwinism,

then what you believe is a falsehood. If you believe any of these propositions, you are, however, in very good company—both numerous and intellectually distinguished company. Quine once said of a misguided critic of his work, "He reads with a broad brush." We are all apt to do this, especially when we try to construe in simple terms the take-home message of work outside our own field. We tend to read, with bold brushstrokes, what we want to find. Each of these four propositions expresses a verdict that is rather more decisive and radical than Gould may have intended, but together they compose a message that is out there, in many quarters. I beg to differ, so it falls to me to dismantle the myth. Not an easy job, since I must painstakingly separate the rhetoric from the reality, all the while fending off—by explaining away—the entirely reasonable presumption that an evolutionist of Gould’s stature couldn’t be wrong in his verdicts, could he? Yes and no. The real Gould has made major contributions to evolutionary thinking, correcting a variety of serious and widespread misapprehensions, but the mythical Gould has been created out of the yearnings of many Darwin-dreaders, feeding on Gould’s highly charged words, and this has encouraged, in turn, his own aspirations to bring down “ultra-Darwinism,” leading him into some misbegotten claims.

If Gould has kept crying wolf, why has he done this? The hypothesis I shall defend is that Gould is following in a long tradition of eminent thinkers who have been seeking skyhooks—and coming up with cranes. Since evolution-
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ary theory has made great progress in recent years, the task of making room for a skyhook has become more difficult, raising the bar for any thinker who wants to find some blessed exemption. By following the repetition of theme and variation in Gould’s work, I will uncover a pattern: each failed attempt defines a small portion of the shadow of his quarry, until eventually the source of Gould’s driving discomfort will be clearly outlined. Gould’s ultimate target is Darwin’s dangerous idea itself; he is opposed to the very idea that evolution is, in the end, just an algorithmic process.

It would be interesting to ask the further question of why Gould is so set against this idea, but that is really a task for another occasion, and perhaps for another writer. Gould himself has shown how to execute such a task. He has examined the underlying assumptions, fears, and hopes of earlier scientists, from Darwin himself through Alfred Binet, the inventor of IQ testing, to Charles Walcott, the (mis)classifier of the Burgess Shale fauna, to name just three of his best-known case histories. What hidden agendas—moral, political, religious—have driven Gould himself? Fascinating though this question is, I am going to resist the temptation to try to answer it, though in due course I will briefly consider, as I must, the rival hypotheses that have been suggested. I have enough to do just defending the admittedly startling claim that the pattern in Gould’s failed revolutions reveals that America’s evolutionist laureate has always been uncomfortable with the fundamental core of Darwinism.

For years I was genuinely baffled by the ill-defined hostility to Darwinism that I encountered among many of my fellow academics, and although they cited Gould as their authority, I figured they were just wishfully misreading him, with a little help from the mass media, always eager to obliterate subtlety and fan the flames of every minor controversy. It really didn’t occur to me that Gould was often fighting on the other side. He himself has been victimized so often by this hostility. Maynard Smith mentions just one example:

One cannot spend a lifetime working on evolutionary theory without becoming aware that most people who do not work in the field, and some who do, have a strong wish to believe that the Darwinian theory is false. This was most recently brought home to me when my friend Stephen Gould, who is as convinced a Darwinist as I am, found himself the occasion of an editorial in the Guardian announcing the death of Darwinism, followed by an extensive correspondence on the same theme, merely because he had pointed out some difficulties the theory still faces. [Maynard Smith 1981, p. 221, as reprinted in Maynard Smith 1988.]

Why should such a “convinced Darwinist” as Gould keep getting himself in trouble by contributing to the public misconception that Darwinism is dead? There is no more committed or brilliant adaptationist than John Maynard Smith, but here I think we see the master napping: he doesn’t ask himself this “why” question. After I began to notice that many of the most important contributions to evolutionary theory have been made by thinkers who were fundamentally ill-at-ease with Darwin’s great insight, I could begin to take seriously the hypothesis that Gould himself is one of these. Making the case for this hypothesis will take patience and hard work, but there’s no avoiding it. The mythology about what Gould has shown and hasn’t shown is so widespread that it will befog all the other issues before us if I don’t do what I can to disperse it first.

2. THE SPANDREL’S THUMB

I think I can see what is breaking down in evolutionary theory—the strict construction of the modern synthesis with its belief in pervasive adaptation, gradualism and extrapolation by smooth continuity from causes of change in local populations to major trends and transitions in the history of life.

—Stephen Jay Gould 1980b

At issue is not the general idea that natural selection can act as a creative force; the basic argument, in principle, is sound. Primary doubt centers on the subsidiary claims—gradualism and the adaptationist program.

—Stephen Jay Gould 1982a

Gould has done much to bring a central theme of Darwinism, that supposed perfection in design is a jury-rigged compromise adopting some improbable pieces of anatomy, to general notice. But some of these essays contain hints that somehow the Darwinian explanation is only partly correct. But is this a serious attack? Not on a closer reading.

—Simon Conway Morris 1991

Gould (1980b, 1982a) sees two main problem elements in the modern synthesis: “pervasive adaptation” and “gradualism.” And he sees them as related. How? He has given somewhat different answers over the years. We can begin with “pervasive adaptation.” To see what the issue is, we should return to the paper cited in the Guardian’s editorial of 1979. The title is a good place to start: “The Spandrels of San Marco and the Panglossian Paradigm: A Critique of the Adaptationist Programme.” In addition to their redefining of “Panglossian,” they introduced another term, “spandrel,” which has proven...
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to be a highly successful coinage in one sense: it has spread through evolutionary biology and beyond. In a recent retrospective essay, Gould put it this way:

Ten years later, my friend Dave Raup ... said to me, "We have all been spandrelized." When your example becomes both generic and a different part of speech, you have won. Call those San Marco spandrels "Kleenex," "Jell-O," and a most emphatically non-metaphorical "Band-Aid." [Gould 1993a, p. 325.]

Ever since Gould and Lewontin, evolutionists (and many others) have spoken of spandrels, thinking that they knew what they were talking about. What are spandrels? A good question. Gould wants to convince us that adaptation is not "pervasive," so he needs to have a term for the (presumably many) biological features that are not adaptations. They are to be called "spandrels." Spandrels are, um, things that aren't adaptations, whatever they are. Gould and Lewontin have shown us, haven't they, that spandrels are ubiquitous in the biosphere? Not so. Once we clear away the confusions about what the term might mean, we will see that either spandrels are not ubiquitous after all, or they are the normal basis for adaptations, and hence no abridgment at all of "pervasive adaptation."

Gould and Lewontin's paper begins with two famous architectural examples, and since a crucial misstep is made at the outset, we must look closely at the text. (One of the effects of classic texts is that people misremember them, having read them hurriedly once. Even if you are familiar with this oft-reprinted beginning, I urge you to read it again, slowly, to see how the misstep happens, right before your eyes.)

The great dome of St Mark's Cathedral in Venice presents in its mosaic design a detailed iconography expressing the mainstays of Christian faith. Three circles of figures radiate out from a central image of Christ: angels, disciples, and virtues. Each circle is divided into quadrants, even though the dome itself is radially symmetrical in structure. Each quadrant meets one of the four spandrels in the arches below the dome. Spandrels—the tapering triangular spaces formed by the intersection of two rounded arches at right angle (figure [10.1])—are necessary architectural by-products of mounting a dome on rounded arches. Each spandrel contains a design admirably fitted into its tapering space. The design is so elaborate, harmonious and purposeful that we are tempted to view it as the starting point of any analysis, as the cause in some sense of the surrounding architecture. But this would invert the proper path of analysis. The system begins with an architectural constraint: the necessary four spandrels and their tapering triangular form. They provide a space in which the mosaicists worked; they set the quadripartite symmetry of the dome above....

Every fan vaulted ceiling must have a series of open spaces along the mid-line of the vault, where the sides of the fans intersect between the pillars (figure [10.2]). Since the spaces must exist, they are often used for ingenious ornamental effect. In King's College Chapel in Cambridge, for example, the spaces contain bosses alternately embellished with the Tudor rose and portcullis. In a sense, this design represents an 'adaptation', but the architectural constraint is clearly primary. The spaces arise as a necessary by-product of fan vaulting; their appropriate use is a secondary effect. Anyone who tried to argue that the structure exists because the alternation of rose and portcullis makes so much sense in a Tudor chapel would be inviting the same ridicule that Voltaire heaped on Dr Pangloss....

Yet evolutionists, in their tendency to focus exclusively on immediate adaptation to local conditions, do tend to ignore architectural constraints and perform just such an inversion of explanation. [Gould 1993a, pp. 147-49.]

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Ten years later, my friend Dave Raup ... said to me, "We have all been spandrelized." When your example becomes both generic and a different part of speech, you have won. Call those San Marco spandrels "Kleenex," "Jell-O," and a most emphatically non-metaphorical "Band-Aid." [Gould 1993a, p. 325.]

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Gould and Lewontin's paper begins with two famous architectural examples, and since a crucial misstep is made at the outset, we must look closely at the text. (One of the effects of classic texts is that people misremember them, having read them hurriedly once. Even if you are familiar with this oft-reprinted beginning, I urge you to read it again, slowly, to see how the misstep happens, right before your eyes.)

The great dome of St Mark's Cathedral in Venice presents in its mosaic design a detailed iconography expressing the mainstays of Christian faith. Three circles of figures radiate out from a central image of Christ: angels, disciples, and virtues. Each circle is divided into quadrants, even though the dome itself is radially symmetrical in structure. Each quadrant meets one of the four spandrels in the arches below the dome. Spandrels—the tapering triangular spaces formed by the intersection of two rounded arches at right angle (figure [10.1])—are necessary architectural by-products of mounting a dome on rounded arches. Each spandrel contains a design admirably fitted into its tapering space. The design is so elaborate, harmonious and purposeful that we are tempted to view it as the starting point of any analysis, as the cause in some sense of the surrounding architecture. But this would invert the proper path of analysis. The system begins with an architectural constraint: the necessary four spandrels and their tapering triangular form. They provide a space in which the mosaicists worked; they set the quadripartite symmetry of the dome above....

Every fan vaulted ceiling must have a series of open spaces along the mid-line of the vault, where the sides of the fans intersect between the pillars (figure [10.2]). Since the spaces must exist, they are often used for ingenious ornamental effect. In King's College Chapel in Cambridge, for example, the spaces contain bosses alternately embellished with the Tudor rose and portcullis. In a sense, this design represents an 'adaptation', but the architectural constraint is clearly primary. The spaces arise as a necessary by-product of fan vaulting; their appropriate use is a secondary effect. Anyone who tried to argue that the structure exists because the alternation of rose and portcullis makes so much sense in a Tudor chapel would be inviting the same ridicule that Voltaire heaped on Dr Pangloss.... Yet evolutionary biologists, in their tendency to focus exclusively on immediate adaptation to local conditions, do tend to ignore architectural constraints and perform just such an inversion of explanation. [Gould 1993a, pp. 147-49.]

First, we should notice that from the outset Gould and Lewontin invite us to contrast adaptationism with a concern for architectural "necessity" or
"constraint"—as if the discovery of such constraints weren't an integral part of (good) adaptationist reasoning, as I have argued in the last two chapters. Now, perhaps we should stop right here and consider the possibility that Gould and Lewontin have been massively misunderstood, thanks to the misfiring rhetoric of this opening passage, rhetoric which they even correct somewhat, in the last sentence quoted above. Perhaps what Gould and Lewontin showed, in 1979, is that we must all be better adaptationists; we should expand our reverse-engineering perspective back onto the processes of R and D, and embryological development, instead of focusing "exclusively on immediate adaptation to local conditions." That, after all, is one of the main lessons of the last two chapters, and Gould and Lewontin could share the credit for drawing it to the attention of evolutionists. But almost everything else that Gould and Lewontin have said militates against this interpretation; they mean to oppose adaptationism, not enlarge it. They call for a "pluralism" in evolutionary biology of which adaptationism is to be just one element, its influence diminished by the other elements, if not utterly suppressed.

The spandrels of San Marco, we are told, "are necessary architectural by-products of mounting a dome on rounded arches." In what sense necessary? The standard assumption among biologists I have asked is that this is somehow a geometric necessity, and hence has nothing whatever to do with adaptationist cost-benefit calculations, since there is simply no choice to be made! As Gould and Lewontin (p. 161) put it, "Spandrels must exist once a blueprint specifies that a dome shall rest on rounded arches." But is that true? It might appear at first as if there were no alternatives to smooth, tapering triangular surfaces in between the dome and the four rounded arches, but there are in fact indefinitely many ways that those spaces could be filled with masonry, all of them about equal in structural soundness and ease of building. Here is the San Marco scheme (on the left) and two variations. The variations are both, in a word, ugly (I deliberately made them so), but that does not make them impossible.

Here there is a terminological confusion that seriously impedes discus-
"constraint"—as if the discovery of such constraints weren't an integral part of (good) adaptationist reasoning, as I have argued in the last two chapters. Now, perhaps we should stop right here and consider the possibility that Gould and Lewontin have been massively misunderstood, thanks to the misfiring rhetoric of this opening passage, rhetoric which they even correct somewhat, in the last sentence quoted above. Perhaps what Gould and Lewontin showed, in 1979, is that we must all be better adaptationists; we should expand our reverse-engineering perspective back onto the processes of R and D, and embryological development, instead of focusing "exclusively on immediate adaptation to local conditions." That, after all, is one of the main lessons of the last two chapters, and Gould and Lewontin could share the credit for drawing it to the attention of evolutionists. But almost everything else that Gould and Lewontin have said militates against this interpretation; they mean to oppose adaptationism, not enlarge it. They call for a "pluralism" in evolutionary biology of which adaptationism is to be just one element, its influence diminished by the other elements, if not utterly suppressed.

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Here there is a terminological confusion that seriously impedes discus-
sion. Does figure 10.3 display three different sorts of spandrels, or does it display a spandrel on the left, and two ugly alternatives to spandrels? Like other specialists, art historians often indulge in both strict and loose usages for their terms. Strictly speaking, the tapering, roughly spherical surface illustrated in figure 10.1, the sort of surface illustrated on the left in figure 10.3, is called a 

**pendentive**, not a **spandrel**. Strictly speaking, spandrels are what remains of a wall once you punch an arch through it, as in figure 10.4. (But even that definition leaves room for confusion. In figure 10.4, are we shown spandrels on the left, and something else on the right, or do “pierced spandrels” count as spandrels, strictly speaking? I don’t know.)

Speaking more loosely, spandrels are places-to-be-dealt-with, and in that looser sense, the three variations in figure 10.3 all count as spandrel varieties. Another variety of spandrel (in that sense) would be a **squinch**, shown in figure 10.5.

But sometimes art historians speak of spandrels when they are talking specifically about pendentives, the variety shown on the left in figure 10.3. In that sense, squinches are not types of spandrels, but rivals to spandrels.

Now, why does all this matter? Because, when Gould and Lewontin say that spandrels are “necessary architectural by-products,” what they say is false, if they are using “spandrel” in the narrow sense (synonymous with “pendentive”) and true only if we understand the term in the loose, all-inclusive sense. But in that sense of the term, spandrels are design **problems**, not **features** that might either be designed (adaptations) or not. Spandrels in the loose sense are indeed “geometrically necessary” in one regard: if you

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**Squinch.** A corbelling, usually a small arch or half-comical niche, which is placed across the corners of a square bay in order to form an octagon suitable for carrying an octagonal cloister-vault or a dome. [Krautheimer 1981.]

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place a dome over four arches, you have what you might call an **obligatory design opportunity**—you have to put something there to hold up the dome—some shape or other, you decide which. But if we interpret spandrels as obligatory places for one adaptation or another, they are hardly a challenge to adaptationism.

But is there nevertheless some other way in which spandrels in the narrow sense—pendentives—truly are nonoptional features of San Marco? That is what Gould and Lewontin seem to be asserting, but if so, they are wrong. Not only were the pendentives just one among many imaginable options; they were just one among the readily available options. Squinches had been a well-known solution to the problem of a dome over arches in Byzantine architecture since about the seventh century.

What the actual design of the San Marco spandrels—that is, pendentives—has going for it are mainly two things. First, it is (approximately) the “minimal-energy” surface (what you would get if you stretched a soap film in a wire model of the corner), and hence it is close to the minimal surface area (and hence might well be viewed as the optimal solution if, say, the number of costly mosaic tiles was to be minimized!). Second, this smooth surface is **ideal** for the mounting of mosaic images—and that is why the

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1. “Whatever the origin of the dome on squinches, however, the importance of the question, it seems to me, has been vastly overplayed. Squinches are an element of construction which can be incorporated into almost any kind of architecture.” (Krautheimer 1981, p. 359.)
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Basilica of San Marco was built: to provide a showcase for mosaic images. The conclusion is inescapable: the spandrels of San Marco aren't spandrels even in Gould's extended sense. They are adaptations, chosen from a set of equipossible alternatives for largely aesthetic reasons. They were designed to have the shape they have precisely in order to provide suitable surfaces for the display of Christian iconography.

After all, San Marco is not a granary; it is a church (but not a cathedral). The primary function of its domes and vaults was never to keep out the rain—there were less expensive ways of doing that in the eleventh century, when these domes were built—but to provide a showcase for symbols of the creed. An earlier church on the site had burned and been rebuilt in 976, but subsequently the Byzantine style of mosaic decoration had provoked the admiration of powerful Venetians who wanted to create a local example. Otto Demus (1984), the great authority on the San Marco mosaics, shows in four magnificent volumes that the mosaics are the raison d'etre of San Marco, and hence of many of its architectural details. In other words, there wouldn't be any such pendentives in Venice if the "environmental problem" of how to display Byzantine mosaic images of Christian iconography had not been posed and this solution found. If you look closely at the pendentives (this is detectable in figure 10.1, but unmistakable if you look at the actual pendentives, as I did on a recent visit to Venice), you will see that care has been taken to round off the transition between the pendentive proper and the arches it connects, the better to provide a continuous surface for the application of mosaics.

Gould and Lewontin's other example from architecture was also ill-chosen, as it turns out, since we simply don't know whether the King's College bosses alternating rose and portcullis are the raison d'etre of the fan vaulting or vice versa. We do know that fan vaulting was not part of the original design of that chapel, but a later revision, a change order introduced years after the construction had begun, for reasons unknown (Fitchen 1961, p. 248). The very heavy (and heavily carved) keystones at the intersections of the ribs of earlier Gothic vaults had been a sort of forced move for builders, as I noted in chapter 8, since they needed the extra weight of this keystone to counteract the rising tendency of the pointed arches, especially during the construction phase, when deformation of partially completed structures was a major problem to be solved. But in late fan vaulting of the King's College type, the purpose of the bosses is probably entirely to provide focal points for ornament. Did the bosses have to be there anyway? No. From an engineering point of view, there could have been neat round holes there, "lanterns" letting in daylight from above if it weren't for the roof. Maybe fan vaulting was chosen by the builders so that the ceiling could carry the Tudor symbols! So the fabled spandrels of San Marco are not spandrels but adaptations after all.2 That is curious, you may think, but not theoretically important, because, as Gould himself has often reminded us, one of Darwin's fundamental messages is that artifacts get recycled with new functions—"exapted," to use Gould and Vrba's coinage (1981). The panda's thumb is not really a thumb, but it is pretty good at doing what it does. Isn't the Gould-Lewontin concept of a spandrel a valuable tool in evolutionary thinking even if its birth was, to exapt yet another famous phrase, a frozen accident of history? Well, what is the function of the term "spandrel" in evolutionary thinking? So far as I know, Gould has never given the term (in application to biology) an official definition, and since the examples he has relied on to exhibit his intended meaning are at best misleading, we are left to our own devices: we should try to find the best, most charitable, interpretation of his texts. When we turn to that task, one point emerges from context with clarity: whatever a spandrel is, it is supposed to be a non-adaptation.

What would be a good architectural example of a spandrel (sensu Gould)? If adaptations are examples of (good, cunning) design, then perhaps a spandrel is a "no-brainer"—a feature exhibiting no design cunning at all. The existence of a doorway—just a rough opening—in a building might seem to be an example, since we would not be particularly impressed by the wisdom of the builder who included such a feature in his house. But there is, after all, a very good reason why dwellings should have doorways. If spandrels are just dead-obvious good solutions to design problems that tend therefore to become part of a relatively unthinking tradition of building, then spandrels abound. In that case, however, they would not be alternatives to adaptation, but examples par excellence of adaptation—either forced moves or, in any event, moves you'd be foolish not to consider. A better sort of example, then, might be what engineers sometimes call a "don't-care": something that has to be one way or another, but that nothing makes better one way than another. If we put a door in the doorway, the

2. I am not the first, I have recently discovered, to note these minor errors in Gould's excursion in art history. Some years ago, two evolutionary biologists were there before me: Alasdair Houston (1990) drew attention to the point about spandrels, pendentives, and squinches; and Tim Clutton-Brock, in a lecture at Harvard, questioned Gould's interpretation of the fan vaulting of King's College Chapel.

It is interesting that these points were overlooked by all the deconstructionists and rhetoricians who contributed essays to a recent book (Selzer 1993) devoted in its entirety to an analysis of the rhetoric of Gould and Lewontin's essay. You might suppose that someone among this group of sixteen humanists would have noticed the factual problems in the fundamental rhetorical device of the essay, but it must be remembered that these sophisticates are interested in "deconstructing knowledge"—which means that they have transcended the stodgy, old-fashioned dichotomy between fact and fiction, and hence are not professionally curious about whether what they read is the truth!
The Spandrel's Thumb was not spandrels but adaptations after all.² That is curious, you may think, but not theoretically important, because, as Gould himself has often reminded us, one of Darwin's fundamental messages is that artifacts get recycled with new functions—"exapted," to use Gould and Vrba's coinage (1981). The panda's thumb is not really a thumb, but it is pretty good at doing what it does. Isn't the Gould-Lewontin concept of a spandrel a valuable tool in evolutionary thinking even if its birth was, to exapt yet another famous phrase, a frozen accident of history? Well, what is the function of the term "spandrel" in evolutionary thinking? So far as I know, Gould has never given the term (in application to biology) an official definition, and since the examples he has relied on to exhibit his intended meaning are at best misleading, we are left to our own devices: we should try to find the best, most charitable, interpretation of his texts. When we turn to that task, one point emerges from context with clarity: whatever a spandrel is, it is supposed to be a non-adaptation.

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Sometimes, however, it does seem that he thinks this is the view to attack. He characterizes adaptationism as "pure adaptationism" and "panadaptationism"—apparently the view that every feature of every organism is to be explained as an adaptation selected for. In her recent book, *The Ant and the Peacock*, the philosopher of biology Helena Cronin is particularly acute in diagnosing this view (Cronin, pp. 66-110). She catches Gould in the act of sliding into exactly this misconstrual:

Stephen Gould talks about 'what may be the most fundamental question in evolutionary theory' and then, significantly, spells out not one question but two: 'How exclusive is natural selection as an agent of evolutionary change? Must all features of organisms be viewed as adaptations?' (Gould 1980[a], p. 49; my emphasis). But natural selection could be the only true begetter of adaptations without having begot all characteristics; one can hold that all adaptive characteristics are the result of natural selection without holding that all characteristics are, indeed, adaptive. [Cronin 1991, p. 86.]

Natural selection could still be the "exclusive agent" of evolutionary change even though many features of organisms were not adaptations. Adaptationists are—and should be—always on the lookout for adaptive explanations of whatever feature captures their attention, but this strategy falls short of committing anybody to the caricature that Gould calls "panadaptationism."

Perhaps what Gould opposes will become clearer if we look at what he recommends in its place. What alternatives to adaptationism did Gould and Lewontin suggest, as components of their recommended pluralism? Chief among them was the idea of a *Bauplan*, a German architectural term that had been adopted by certain continental biologists. The term would usually be translated in English as "ground plan" or "floor plan"—the basic outline of the structure as seen from above. It is curious that an architectural term should be highlighted in a counteradaptationist campaign, but it makes a certain daft sense when you see how the original *Bauplan* theorists pushed it. Adaptation, they said, could explain superficial modifications of the design of organisms to fit the environment, but not the fundamental features of living things: "The important steps in evolution, the construction of the *Bauplan* itself and the transition between *Bauplans*, must involve some other unknown, and perhaps 'internal' mechanism" (Gould and Lewontin 1979, p. 159). The floor plan is not designed by evolution, but just somehow given? Sounds a bit fishy, doesn't it? Were Gould and Lewontin buying this radical idea from the continent? Not for a moment. They quickly (p. 159) granted that English biologists had been right "in rejecting this strong form as close to an appeal to mysticism."
door will need hinges, but should they go on the left or the right? Perhaps nobody cares, so a coin is flipped, and hinges on the left get installed. If other builders copy the result unthinkingly, establishing a local tradition (reinforced by the latchmakers, who make latches for left-hinged doors only), this might be a spandrel masquerading as an adaptation. "Why are all the doors in this village hinged on the left?" would be a classic adaptationist question, to which the answer would be: "No reason. Just historical accident." So is that a good architectural example of a spandrel? Perhaps, but, as the example of the autumn leaves in the preceding chapter showed, it is never a mistake to ask the adaptationist's "why" question, even when the true answer is that there is no reason. Are there many features in the biosphere that exist for no reason? It all depends on what counts as a feature. Trivially, there are indefinitely many properties (e.g., the elephant's property of having more legs than eyes, the daisy's property of buoyancy) that are not themselves adaptations, but no adaptationist would deny this. Presumably, there is a more interesting doctrine that Gould and Lewontin are urging us to abandon.

What is the doctrine of "pervasive adaptation," then, that Gould supposes such an admission of widespread spandrels would overthrow? Let us consider the most extreme form of Panglossian adaptationism imaginable—the view that every designed thing is optimally designed. A sidelong glance at human engineering will show that even this view not only permits but requires the existence of plenty of undesigned stuff. Imagine, if you can, some masterpiece of human engineering—the perfectly designed widget-factory, energy-efficient, maximally productive, minimally expensive to operate, maximally humane to its workers, simply unimprovable in any dimension. The wastepaper collection system, for example, makes recycling by type of wastepaper maximally convenient and agreeable to the staff, at minimal energy costs, and so forth. A Panglossian triumph, it seems. But wait—what is the wastepaper for? It's not for anything. It's a by-product of the other processes, and the wastepaper collection system is for dealing with it. You can't give an adaptationist explanation of why the disposal/recycling system is optimal without presupposing that the wastepaper itself is just...waste! Of course, you can go on and ask whether the clerical operations could be made "paperless" by better use of computers, but if that happens not to be the case for one reason or another, there will still be wastepaper to deal with, and other wastes and by-products as well in any case, so there will always be plenty of undesigned features in a system that is maximally well designed. No adaptationist could be such a "pervasive" adaptationist as to deny it. The thesis that every property of every feature of everything in the living world is an adaptation is not a thesis anybody has ever taken seriously, or implied by what anybody has taken seriously, so far as I know. If I am wrong, there are some serious loonies out there, but Gould has never shown us one.

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Moreover, Gould, in spite of the appeal to pluralism in the co-authored paper, has persisted in describing it as laying waste to adaptationism (e.g., 1993a), and has held out for a "non-Darwinian" interpretation of its central concept, spandrels. It may have occurred to you that I have overlooked an obvious interpretation of spandrels: perhaps spandrels are just QWERTY phenomena. QWERTY phenomena, you recall, are constraints, but constraints with an adaptive history and hence an adaptationist explanation. Gould himself briefly considered this alternative (1982a, p. 383): "If the channels [that constrain current options] are set by past adaptations, then selection remains preeminent, for all major structures are either expressions of immediate selection, or channeled by a phylogenetic heritage of previous selection." Nicely put, but he promptly rejected it, calling it Darwinian (which it certainly is), and recommending an alternative "non-Darwinian version" which he described as "not widely appreciated but potentially fundamental." Spandrels, he then suggested (p. 383), aren't the frozen constraints created by earlier adaptations; they are exaptations. What contrast was he trying to draw?

I think he saw the difference between the exploitation of something previously designed, and the exploitation of something originally undesigned, and was claiming that it was an important difference. Perhaps. Here is some indirect textual evidence for that reading. A recent article in the Boston Globe quotes the linguist Samuel Jay Keyser of MIT:

"Language may well be a spandrel of the mind," Keyser says, and then waits patiently while his questioner looks "spandrel" up in the dictionary—The first builder who supported domes with arches created spandrels by accident [emphasis added], and at first builders paid no attention to spandrels and decorated only the arches, Keyser says. But after a couple of centuries, builders began focusing on and decorating the spandrels. In the

3. In his own discussion of the original QWERTY phenomenon (1991a), Gould makes a useful point (1991a, p. 71), but does not develop it further, so far as I know: because of the curious historical sequence of events that led to the general adoption of the standard QWERTY typewriter keyboard, "An array of competitions that would have tested QWERTY were never held." That is, it is simply irrelevant to ask whether QWERTY is a better design than alternatives X, Y, and Z, since those alternatives were never pitted against QWERTY in the marketplace or the design workshop. They just never came up at a time when, it seems, they could have made a difference. Adaptationists should be alert to the fact that, even though whatever we see in nature has been "test.ed against all comers" and not found wanting, only a Vanishingly small (and biased) subset of all the imaginable competitions has ever been held. The inevitable parochiality of all actual tournaments means that one must be cautious in characterizing the virtues of the winners. An old Downeast joke makes the same point more succinctly: "Mornin', Edna." 'Mornin', Bessie. How's yer husband?" 'Compared to what?"
Moreover, Gould, in spite of the appeal to pluralism in the co-authored paper, has persisted in describing it as laying waste to adaptationism (e.g., 1993a), and has held out for a "non-Darwinian" interpretation of its central concept, spandrels. It may have occurred to you that I have overlooked an obvious interpretation of spandrels: perhaps spandrels are just QWERTY phenomena. QWERTY phenomena, you recall, are constraints, but constraints with an adaptive history and hence an adaptationist explanation. Gould himself briefly considered this alternative (1982a, p. 383): "If the channels [that constrain current options] are set by past adaptations, then selection remains preeminent, for all major structures are either expressions of immediate selection, or channeled by a phylogenetic heritage of previous selection." Nicely put, but he promptly rejected it, calling it Darwinian (which it certainly is), and recommending an alternative "non-Darwinian version" which he described as "not widely appreciated but potentially fundamental." Spandrels, he then suggested (p. 383), aren't the frozen constraints created by earlier adaptations; they are exaptations. What contrast was he trying to draw?

I think he saw the difference between the exploitation of something previously designed, and the exploitation of something originally undesigned, and was claiming that it was an important difference. Perhaps. Here is some indirect textual evidence for that reading. A recent article in the Boston Globe quotes the linguist Samuel Keyser of MIT:

"Language may well be a spandrel of the mind," Keyser says, and then waits patiently while his questioner looks "spandrel" up in the dictionary—The first builder who supported domes with arches created spandrels by accident [emphasis added], and at first builders paid no attention to spandrels and decorated only the arches, Keyser says. But after a couple of centuries, builders began focussing on and decorating the spandrels. In the

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same way, Keyser says language—that is, the ability to convey information by speech—may have been a thinking and communicating “spandrel” accidentally created by the development of some cultural “arch.” ... "Language is very likely an accidental artifact of some evolutionary quirk of mind."[Robb 1991]

Perhaps Keyser has been misquoted—I am always cautious about accepting any journalist’s account of someone's words, having been burned badly myself—but if the quotation is accurate, then for Keyser spandrels are originally accidents, not necessities, don’t-cares, or QWERTY phenomena. Once, when I was working at a bronze-casting foundry in Rome, we had an explosion in a cast as we were filling it; molten bronze went splashing all over the floor. One of the splashes hardened into a fantastic lacy shape that I promptly appropriated and turned into a sculpture. Was I exapting a spandrel? (The Dadaist artist Marcel Duchamp, in contrast, would not have been exapting a *spandrel* when he appropriated a urinal as his *objet trouve* and called it a sculpture, since the urinal had a function in its earlier life.)

Gould himself (1993a, p. 31) has quoted this newspaper story with approval, not noticing that Keyser has the art history wrong, and not expressing any disagreement with Keyser’s definition of a spandrel as an accident. So perhaps Keyser is right about the meaning of the term: spandrels are just accidents available for exaptation. Gould introduced “exaptation” in an article he co-authored with Elizabeth Vrba in 1982, “Exaptation: A Missing Term in the Science of Form.” Their intent was to contrast exaptation to adaptation. Their chief stalking horse, however, was an astonishingly ill-favored term that had gained some currency in textbooks on evolution: *preadaptation*.

*Preadaptation* seems to imply that the proto-wing, while doing something else in its incipient stages, knew where it was going—predestined for a later conversion to flight. Textbooks usually introduce the word and then quickly disclaim any odor of foreordination. (But a name is obviously ill-chosen if it cannot be used without denying its literal meaning.) [Gould 1991b, p. 144a]

"Preadaptation" was a terrible term, for exactly the reasons Gould gives, but notice that he is not claiming that the targets of his criticism committed the major mistake of granting foresight to natural selection—he admits that they "quickly disclaimed" this heresy in the very act of introducing the term. They were making the minor mistake of choosing a usage perversely likely to foster this confusion. Switching from "preadaptation" to "exaptation" might well be seen, then, as a wise reform of usage, better suited to drive home the orthodox view of adaptationists. Gould, however, resisted this reformist interpretation. He wanted exaptation, and spandrels, to present a "potentially fundamental" and "non-Darwinian" alternative.

Elizabeth Vrba and I have proposed that the restrictive and confusing word "preadaptation" be dropped in favor of the more inclusive term "exaptation"—for any organ not evolved under natural selection for its current use—either because it performed a different function in ancestors (classical preadaptation) or because it represented a nonfunctional part available for later co-option. [Gould 1991b, p. 144a.]

But, according to orthodox Darwinism, every adaptation is one sort of exaptation or the other—this is trivial, since no function is eternal; if you go back far enough, you will find that every adaptation has developed out of predecessor structures each of which either had some other use or no use at all. The only phenomena that Gould’s exaptation revolution would rule out are the phenomena that orthodox adaptationists "quickly" disavowed in any case: planned-for preadaptations.

The spandrel revolution (against panadaptationism) and the exaptation revolution (against preadaptationism) evaporate on closer inspection, since both panadaptationism and preadaptationism have been routinely shunned by Darwinians ever since Darwin himself. These nonrevolutions not only do not challenge any orthodox Darwinian tenet; the coinages they introduce are as likely to confuse as the coinages they were supposed to replace.

It is hard to be a revolutionary if the establishment keeps co-opting you. Gould has often complained that his target, neo-Darwinism, recognizes the very exceptions he wants to turn into objections, "and this imposes a great frustration upon anyone who would characterize the modern synthesis in order to criticize it" (Gould 1980b, p. 130).

The modern synthesis has sometimes been so broadly construed, usually by defenders who wish to see it as fully adequate to meet and encompass current critiques, that it loses all meaning by including everything.... Stebbins and Ayala [two eminent defenders] have tried to win an argument by redefinition. The essence of the modern synthesis must be its Darwinian core. [Gould 1982a, p. 382.]

It is surprising to see a Darwinian give anything an essence, but we can take Gould’s point, if not his language, there is *something* about the modern synthesis that he wants to overthrow, and before you can overthrow something you must pin it down. He has sometimes claimed (e.g., 1983a) he could see the modern synthesis doing his work for him, "hardening" into a brittle orthodoxy that would be easier to attack. If only! In fact, no sooner has he gone into battle than the modern synthesis has shown its flexibility, readily absorbing his punches, to his frustration. I think he is right, however, that the modern synthesis has a "Darwinian core," and I think he is right that it is his target; he just hasn’t yet put his finger on it himself.

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If the case against "pervasive adaptation" has vanished, then, what about
the case against gradualism, the other main element in the modern synthesis that Gould sees "breaking down"? Gould's attempted revolution against gradualism was actually his first; it opened with a salvo in 1972 which introduced yet another familiar coinage to the vocabulary of evolutionists and onlookers alike: punctuated equilibrium.

3. PUNCTUATED EQUILIBRIUM: A HOPEFUL MONSTER

Punctuated equilibrium has finally obtained an unambiguous majority—that is, our theory is now 21 years old. We also, with parental pride (and therefore, potential bias), believe that primary controversy has ceded to general comprehension and that punctuated equilibrium has been accepted by most of our colleagues (a more conventional sort of majority) as a valuable addition to evolutionary theory.

—STEPHEN JAY GOULD and NILES ELDREDGE 1993, p. 223

What needs to be said now, loud and clear, is the truth: that the theory of punctuated equilibrium lies firmly within the neo-Darwinian synthesis. It always did. It will take time to undo the damage wrought by the overblown rhetoric, but it will be undone.

—RICHARD DAWKINS 1986a, p. 251

Niles Eldredge and Gould co-authored the paper that introduced the term, "Punctuated Equilibria: An Alternative to Phyletic Gradualism" (1972). Whereas orthodox Darwinians, according to them, tended to envision all evolutionary change as gradual, they argued that, on the contrary, it proceeded by jerks: long periods of changelessness or stasis—equilibrium—interrupted by sudden and dramatic brief periods of rapid change—punctuations. The basic idea is often illustrated by contrasting a pair of trees of life (figure 10.6).

We can suppose that the horizontal dimension registers some one aspect of phenotypic variation or body design—we'd need a multidimensional space to represent it all, of course. The orthodox view on the left is pictured as showing that all motion through design space (that is, to the left or right in the diagram) is at a more or less steady pace. Punctuated equilibrium, in contrast, shows long periods of unchanged design (the vertical line segments) interrupted by "instantaneous" sideways leaps in design space (the horizontal segments). To see the central claim of their theory, trace the evolutionary history of the species at K in each picture. The orthodox picture shows a more or less steady rightward trend from the diagram's Adam species, A. Their proposed alternative agrees that K is a descendant of A, and that it accomplished the same rightward shift in Design Space in the same amount of time, but by fits and starts, not a steady climb. (These diagrams can be tricky to think about; the difference between a ramp and a staircase is the point of the contrast, but the giant steps are the sideways moves, not the vertical bits, which are the boring periods of "motion" through time only, with no motion through design space.)

There is a familiar trio of reactions by scientists to a purportedly radical hypothesis: (a) "You must be out of your mind!", (b) "What else is new? Everybody knows that!", and, later—if the hypothesis is still standing—(c) "Hmm. You might be on to something!" Sometimes these phases take years to unfold, one after another, but I have seen all three emerge in near synchrony in the course of a half-hour's heated discussion following a conference paper. In the case of the hypothesis of punctuated equilibrium, the phases are particularly pronounced, in large part because Gould has several times changed his mind about just what he and Eldredge were claiming. In its first appearance, the thesis of punctuated equilibrium was presented not as a revolutionary challenge at all, but as a conservative correction of an illusion to which orthodox Darwinians had succumbed: paleontologists were simply mistaken in thinking that Darwinian natural selection should leave a fossil record showing lots of intermediate forms." There was no

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offering repeated denials that he had ever meant anything so outrageous. In
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As Gould and Eldredge have themselves pointed out, there was an obvious
problem of scale in such diagrams as figure 10.6. What if we zoomed way in
on the orthodox picture and found that, once we enlarged it sufficiently, it
looked like this:

\[ \text{FIGURE 10.7} \]

At some level of magnification, any evolutionary ramp must look like a
staircase. Is figure 10.7 a picture of punctuated equilibrium? If it is, then
orthodox Darwinism was already a theory of punctuated equilibrium. Even

the most extreme gradualist can allow that evolution could take a breather for
a while, letting the vertical lines extend indefinitely through time until some
new selection pressure somehow arose. During this period of stasis, selection
pressure would be conservative, keeping the design roughly constant by
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point of disagreement being offered by Eldredge and Gould here, or were
they merely offering an interesting observation about the variability in tempo
of evolutionary processes and its predictable effects on the fossil record?

Punctuationists typically draw the punctuation parts of their revolutionary
diagrams absolutely horizontal (to make strikingly clear that they are
presenting a true alternative to the rampant ramp-view of orthodoxy). This
makes it look as if each of the design revisions illustrated takes place in a
twinkling, in no time at all. But that is just a misleading artifact of the huge
vertical scale adopted, which shows millions of years to the inch. The
sideways motion is not really instantaneous. It is only "geologically instan-
taneous."

An isolated population may take a thousand years to speciate, and its
transformation would therefore appear glacially slow if measured by the
irrelevant scale of our personal lives. But a thousand years, appropriately
recorded in geological time, is only an unresolvable moment, usually pre-
served on a single bedding plane [in fossil-bearing rock], in a lifetime of
species that often live for several million years in stasis. [Gould 1992a, pp.
12-14.]

So suppose we zoom in on one of these thousand-year instants, changing
the vertical scale of the time dimension by a few orders of magnitude to see
what might actually be going on (figure 10.8). The horizontal step taken
between time \( t \) and time \( t' \) will have to be stretched out somehow, and we
must turn it into relatively big steps or little steps or tiny steps, or some
combination thereof.

Were any of the possibilities revolutionary? What exactly were Eldredge
and Gould maintaining? Here their respective views diverged somewhat, at
least for a while. The view was revolutionary, Gould claimed, because it
maintained that the punctuations were not just business-as-usual evolution,
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![Diagram](image)

**FIGURE 10.7**

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Speciation is not always an extension of gradual, adaptive allelic substitution to greater effect, but may represent, as Goldschmidt argued, a different style of genetic change—rapid reorganization of the genome, perhaps non-adaptive. [Gould 1980b, p. 119.]

Speciation itself, in this view, is not an effect of accumulated adaptations gradually driving populations apart but, rather, a cause with its own, non-Darwinian explanation:

But in saltational, chromosomal speciation, reproductive isolation comes first and cannot be considered as an adaptation at all. . . . We can, in fact, reverse the conventional view and argue that speciation, by forming new entities stochastically, provides raw material for selection. [Gould 1980b, p. 124.]

This suggestion, which I call Gould's leap, is represented in the right-hand graph in figure 10.8. Only part of the punctuation process, the gradual, cleaning-up process at the end, is "Darwinian," Gould claimed:

If new Baupläne often arise in an adaptive cascade following the saltational origin of a key feature, then part of the process is sequential and adaptive, and therefore Darwinian; but the initial step is not, since selection does not play a creative role in building the key feature. [Gould 1982a, p. 383.]

It is this "creative role" of something other than selection that caught the skeptical attention of Gould's colleagues. To get clear about what caused the furor, we need to note that our diagram in figure 10.8 is really unable to distinguish several crucially different hypotheses. The trouble with the diagram is that it needs more dimensions, so we can compare the steps in genotype space (the typographical steps in the Library of Mendel) to the steps in phenotype space (the design innovations in Design Space) and then evaluate these differences on a fitness landscape. As we have seen, the relations between recipe and result are complex, and many possibilities might be illustrated. We saw in chapter 5 that a small typographical change in the genome could in principle have a large effect on the phenotype expressed. We also saw, in chapter 8, that some typographical changes in the genome can have no effect at all on the phenotype—there are over a hundred different ways of "spelling" lysozyme, for instance, and hence more than a hundred equivalent ways of spelling the order for lysozyme in DNA codons. We know, then, that at one extreme there can be organisms so similar in design as to be indistinguishable that nevertheless have large differences in their DNA—for instance, you and whoever that person is for whom you are often mistaken (your Doppelgänger—no philosophy book would be complete with mentioning doppelgängers ). At the other extreme, there can be organisms that are bizarrely different in appearance, but almost identical genetically. A single mutation in just the wrong place can produce a monster—the medical term for such deformed offspring is terata, Greek (and Latin) for "monsters." And there can also be organisms that are almost identical in appearance and structure, and almost identical in DNA, but dramatically different in fitness—for instance, fraternal twins one of whom happens to have a gene that gives it either immunity or susceptibility to some disease.

As Ernst Mayr (1960) has observed, there are three different reasons we could call a mutation big: it is a big step in the Library of Mendel; it produces a radical difference in phenotype (a monster); it produces (one way or another) a big increase in fitness—a lot of lifting, in our metaphor for good work done by design changes.

It is possible for the molecular replicating machinery to take large steps in the Library of Mendel—there are cases in which whole chunks of text get transposed, inverted, or deleted in a single copying "mistake." It is also

5. For an introduction to the term, see Dietrich's essay "Macromutation" in the excellent new sourcebook, *Keywords in Evolutionary Biology*, edited by Keller and Lloyd (1992).
Speciation is not always an extension of gradual, adaptive allelic substitution to greater effect, but may represent, as Goldschmidt argued, a different style of genetic change—rapid reorganization of the genome, perhaps non-adaptive. [Gould 1980b, p. 119.]

Speciation itself, in this view, is not an effect of accumulated adaptations gradually driving populations apart but, rather, a cause with its own, non-Darwinian explanation:

But in saltational, chromosomal speciation, reproductive isolation comes first and cannot be considered as an adaptation at all. . . . We can, in fact, reverse the conventional view and argue that speciation, by forming new entities stochastically, provides raw material for selection. [Gould 1980b, p. 124.]

This suggestion, which I call Gould's leap, is represented in the right-hand graph in figure 10.8. Only part of the punctuation process, the gradual, cleaning-up process at the end, is "Darwinian," Gould claimed:

If new Baupläne often arise in an adaptive cascade following the saltational origin of a key feature, then part of the process is sequential and adaptive, and therefore Darwinian; but the initial step is not, since selection does not play a creative role in building the key feature. [Gould 1982a, p. 383.]

FIGURE 10.8

Gould's leap

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A large leap in any of these three spaces, or a saltation, may also be called a macromutation (meaning a big mutation, not just a mutation in what I have called a macro—a macromolecular subsystem). As Ernst Mayr (1960) has observed, there are three different reasons we could call a mutation big: it is a big step in the Library of Mendel; it produces a radical difference in phenotype (a monster); it produces (one way or another) a big increase in fitness—a lot of lifting, in our metaphor for good work done by design changes.

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possible for typographical differences to accumulate slowly (and, in general, randomly) over a long time in the large portion of DNA that never gets expressed, and if these accumulated changes suddenly got expressed, thanks to some transposing error, a huge phenotypic effect would be expected. But it is only when we turn to the third sense of macromutation—large differences in fitness—that we can get clear about what seemed to be radical in Gould's proposal. The terms "saltation" and "macromutation" have tended to be used to describe a successful move, a creative move, in which offspring in a single generation shift from one region of Design Space to another and prosper as a result. The idea had been promoted by Richard Goldschmidt (1933, 1940), and made unforgettable by his catchphrase: "hopeful monsters." What made his work notorious was that he claimed that such leaps were necessary for specification to occur.

This suggestion had been roundly rejected by neo-Darwinian orthodoxy, for the reasons we have already considered. Even before Darwin, the received wisdom of biologists was, as Linnaeus said in his classic work of taxonomy (1751), "Natura non facit saltus"—nature does not make leaps—and this was one maxim that Darwin didn't just leave untouched; he provided enormous support for it. Large leaps sideways in a fitness landscape will almost never be to your benefit; wherever you currently find yourself, you are where you are because this has been a good region of Design Space for your ancestors—you are near the top of some peak or other in the space—so, the bigger the step you take (jumping randomly, of course), the more likely you are to jump off a cliff—into the low country, in any case (Dawkins 1986a, ch. 9). According to this standard reasoning, it is no accident that monsters are virtually always hopeless. That is what made Goldschmidt's views so heretical; he knew and accepted that this was true in general, but proposed that nevertheless the extremely rare exceptions to this rule were the main lifters of evolution.

Gould is a famous defender of underdogs and outcasts, and he deplored the "ritualistic ridicule" (Gould 1982b, p. xv) to which Goldschmidt had been subjected by the orthodox. Was Gould going to try to rehabilitate Goldschmidt? Yes and no. In "Return of the Hopeful Monster" (in Gould 1980b), Gould complained that "defenders of the synthetic theory made a caricature of Goldschmidt's ideas in establishing their whipping boy." So it seemed to many biologists that Gould was arguing that punctuated equilibrium was a theory of Goldschmidtian speciation through macromutation. To them it seemed that Gould was trying to wave his wonderful historian's wand over the tarnished reputation of Goldschmidt, and bring his ideas back into favor. Here the mythic Gould, Refuter of Orthodoxy, seriously got in the way of the real Gould, so that even his colleagues succumbed to the temptation to read what he wrote with a broad brush. They scoffed in disbelief, and then, when he denied that he was endorsing—had ever endorsed—Goldschmidt's salutationism, they scoffed all the more derivatively. They knew what he'd said.

But did they? I must admit that I thought they did until Steve Gould insisted to me that I should check all his various publications, and see for myself that his opponents were foisting a caricature on him. He struck a nerve; no one knows better than I how frustrating it is to have the skeptics hang a crude but convenient label on one's subtle view. (I'm the guy who reputedly denies that people experience colors or pains, and thinks that thermostats think—just ask my critics.) So I checked. He chose to dub his denial of gradualism "the Goldschmidt break" (Gould 1980b), and recommended for serious consideration—without endorsing—some radical Goldschmidtian views, but in the same paper he was careful to say, "We do not now accept all his arguments about the nature of variation." In 1982, he made it clear that the only feature of Goldschmidt's view he was endorsing was the idea of "small genetic changes producing large effects by altering rates of development" (Gould 1982d, p. 338), and in his introduction to the reprinting of Goldschmidt's notorious book, he expanded on this point:

Darwinians, with their traditional preferences for gradualism and continuity, might not shout hosannas for large phenotypic shifts induced rapidly by small genetic changes that affect early development; but nothing in Darwinian theory precludes such events, for the underlying continuity of small genetic changes remains. [Gould 1982b, p. xix.]

Nothing revolutionary, in other words:

One may be excused for retorting: "so what else is new?" Has any biologist ever denied it? But ... progress in science often demands the recovery of ancient truths and their rendering in novel ways. [Gould 1982d, pp. 343-44.]

Still, he could not resist the urge to describe this possibly underappreciated fact about development as a non-Darwinian creative force in evolution, "because the constraints that it imposes upon the nature of phenotypic change guarantee that small and continuous Darwinian variation is not the raw material of all evolution," for it "relegates selection to a negative role (eliminating the unfit) and assigns the major creative aspect of evolution to variation itself" (Gould 1982d, p. 340).

It is still not clear how much importance to assign to this possibility in principle, but, in any event, Gould has not pursued it further: "Punctuated equilibrium is not a theory of macromutation" (Gould 1982c, p. 88). Confusion on this score still abounds, however, and Gould has had to keep issuing his disclaimers: "Our theory entails no new or violent mechanism,
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but only represents the proper scaling of ordinary events into the vastness of geological time" (Gould 1992b, p. 12).

So this was a false-alarm revolution that was largely if not entirely in the eyes of the beholders. But in that case, the view we find Gould and Eldredge maintaining once we zoom in beyond the misleading time-squashing of their geological diagrams, is not the rightmost doozy in figure 10.8 after all, but one of the other, gradual, nonviolent paths illustrated. As Dawkins has noted, the way in which Eldredge and Gould challenged "gradualism" was not, in the end, by positing some exciting new nongradualism, but by saying that evolution, when it occurred, was indeed gradual—but most of the time it was not even gradual; it was at a dead stop. The lefthand diagram in figure 10.6 is supposed to represent orthodoxy, but the feature of it that their theory challenged was not its gradualism—once we get the scale right, they are gradualists themselves. The feature they were challenging was what Dawkins (1986a, p. 244) calls "constant speedism."

Now, has neo-Darwinian orthodoxy ever been committed to constant speedism? In their original paper, Eldredge and Gould claimed that paleontologists were mistaken in thinking that orthodoxy required constant speedism. Was Darwin himself a constant speedist? Darwin often, and correctly, harped on the claim that evolution could only be gradual (at best, you might say). As Dawkins (1986a, p. 145) says, "For Darwin, any evolution that had to be helped over the jumps by God was not evolution at all. It made a nonsense of the central point of evolution. In the light of this, it is easy to see why Darwin constantly reiterated the gradualness of evolution." But documentary evidence in support of the claim that he was committed to constant speedism is not just hard to find; there is a famous passage in which Darwin clearly expresses the opposite view, the view that could be called—in two words—punctuated equilibrium:

Many species once formed never undergo any further change ...; and the periods, during which species have undergone modification, though long as measured by years, have probably been short in comparison with the periods during which they retain the same form. [Origin, 4th and subsequent eds; see Peckham 1959, p. 727.]

Ironically, however, Darwin put just one diagram in Origin, and it happens to show steadily sloping ramps. Steven Stanley, another major exponent of punctuated equilibrium, reprints this diagram in his book (Stanley 1981, p. 36) and makes the inference explicit in his caption.

One effect of such claims is that today there is undoubtedly a tradition imputing constant speedism either to Darwin himself or to neo-Darwinian orthodoxy. For instance, Colin Tudge, a good science journalist, writing about Elizabeth Vrba's recent claims concerning the pulse of evolution,

![Punctuated Equilibrium: A Hopeful Monster](image)

points to the presumed implications for orthodoxy of current research on the evolution of impalas and leopards:

Traditional Darwinism would predict a steady modification of the impala over 3 million years, even without climatic change, because it still needs to outrun leopards. But, in fact, neither impalas nor leopards have changed very much. They are both too versatile to be worried by climatic change, and competition between them and with their own kind does not—as Darwin supposed—provide sufficient selective pressure to cause them to alter. [Tudge 1993, p. 35.]

Tudge's presumption that the discovery of three million years of stasis in the impala and leopard would confound Darwin is a familiar one, but it is an artifact, direct or indirect, of a particular forced reading of the "ramps" in Darwin's (and other orthodox) diagrams.

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FIGURE 10.9

The tree of life published by Darwin in the Origin (1859, p. 117). The tree depicts a gradualistic pattern of evolution. Each fanlike pattern represents the slow evolutionary divergence of populations. Darwin believed that new species, and eventually new genera and families, formed by this kind of slow divergence. [Stanley 1981.]

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change does not usually occur by imperceptibly gradual alteration of entire species but rather [emphasis added] by isolation of small populations and their geologically instantaneous transformation into new species. [Gould 1992a, p. 12.]

This passage invites us to believe that evolutionary change could not be both "geologically instantaneous" and "imperceptibly gradual" at the same time. But that is just what evolutionary change must be when there are no saltations. Dawkins dramatizes the point by passing along an eye-opening thought experiment by the evolutionist G. Ledyard Stebbins, who imagines a mouse-sized mammal for which he postulates such a tiny selection pressure in favor of increased size that there would be no increase in size measurable by biologists studying the animal.

As far as the scientist studying evolution on the ground is concerned, then, these animals are not evolving at all. Nevertheless they are evolving, very slowly at a rate given by Stebbins' mathematical assumption, and even at this slow rate, they would eventually reach the size of elephants. How long would this take?... Stebbins calculates that at his assumed very slow rate of evolution, it would take about 12,000 generations... Assuming a generation time of five years, which is longer than that of a mouse but shorter than that of an elephant, 12,000 generations would occupy about 60,000 years. 60,000 years is too short to be measured by ordinary geological methods of dating the fossil record. As Stebbins says, The origin of a new kind of animal in 100,000 years or less is regarded by paleontologists as "sudden" or "instantaneous". [Dawkins 1986a, p. 242.]

Certainly Gould would not call such a locally imperceptible mouse-to-elephant change a violation of gradualism, but in that case his own opposition to gradualism is left with no support at all from the fossil record. In fact, he grants this (1982a, p. 383)—the only evidence that his own field of paleontology is able to provide in opposition to gradualism goes in the wrong direction. Gould may hanker for evidence of a revolutionary speed-up of one kind or another, but the fossil record could only show periods of stasis that suggest that evolution is often not even gradual.

But perhaps this awkward fact can be turned to good use: perhaps the challenge to orthodoxy should be, not that it can't account for the punctuations, but that it can't account for the equilibria! Perhaps Gould's challenge to the modern synthesis should be that it is committed to constant speedism after all: that, although Darwin didn't positively deny equilibrium (indeed, he asserted that it occurs), he can't actually explain equilibrium when it does occur, and such equilibrium or stasis, it might be argued, is a major pattern in the world in need of explanation. This is in fact the next direction Gould turned in his attack on the modern synthesis.

How can we claim to understand evolution if we only study the percent or two of phenomena that construct life's directional history and leave the vast field of straight-growing bushes—the story of most lineages most of the time—in the limbo of conceptual oblivion? [Gould 1993c, p. 16.]

But this path has problems. First, we must be careful not to make the error that is the mirror image of Gould's error about panadaptationism. We must not make the error of "pene-equilibriumism." However striking or "pervasive" the pattern of stasis turns out to be, we know in advance that most lineages do not exhibit stasis. Far from it. Remember our difficulties in coloring in Lulu and her conspecifics in chapter 4? Most lineages soon die out, never having time to establish stasis; we will only "see" a species where there is something salient and stable in the record. The "discovery" that all species exhibit stasis much of the time is like the discovery that all droughts last longer than a week. We wouldn't notice that there was a drought if it wasn't a long-lasting phenomenon. So, since a modicum of stasis is a precondition for the identification of a species, the fact that all species exhibit some degree of stasis is merely true by definition.

Nevertheless, the phenomenon of stasis might be a real one in need of explanation. We should ask not why species exhibit stability (something true by definition) but why there are salient, identifiable species—that is, why lineages go stable at all. But even here, neo-Darwinism has several obvious adaptationist explanations for why stasis should often occur in a lineage. We have already seen the primary one several times: every species is—must be—a going concern, and going concerns must be conservative; most deviations from the time-tested tradition will be quickly punished by extinction. Eldredge himself (1989) has suggested that a major reason for stasis is "habitat tracking." Sterelny (1992, p. 45) describes it this way:

As the environment changes, organisms may react by tracking their old habitat. They might move north as the climate cools, rather than by evolving adaptations to the cold. [This is not a mistake—Sterelny is a Southern Hemisphere philosopher of biology! ] Selection will usually drive tracking. For migrants that follow the habitat (personally or by reproductive dispersion) will typically be fitter than the population fragment that fails to move, for the residual fragment will be less well adapted to the new environment and will be faced with new competition from other migrants tracking their old habitat.

Note that habitat tracking is as much a "strategy" of plants as of animals. Indeed, some of the clearest cases of speciation invoke this phenomenon. As the iccap recedes after an ice age, the range of some Northern Asian plant spreads to the north year after year, "following" the ice, and spreading east
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But this path has problems. First, we must be careful not to make the error that is the mirror image of Gould's error about panadaptationism. We must not make the error of "panequilibriumi sm." However striking or "pervasive" the pattern of stasis turns out to be, we know in advance that most lineages do not exhibit stasis. Far from it. Remember our difficulties in coloring in Lulu and her conspecifics in chapter 4? Most lineages soon die out, never having time to establish stasis; we will only "see" a species where there is something salient and stable in the record. The "discovery" that all species exhibit stasis much of the time is like the discovery that all droughts last longer than a week. We wouldn't notice that there was a drought if it wasn't a long-lasting phenomenon. So, since a modicum of stasis is a precondition for the identification of a species, the fact that all species exhibit some degree of stasis is merely true by definition.

Nevertheless, the phenomenon of stasis might be a real one in need of explanation. We should ask not why species exhibit stability (something true by definition) but why there are salient, identifiable species—that is, why lineages go stable at all. But even here, neo-Darwinism has several obvious adaptationist explanations for why stasis should often occur in a lineage. We have already seen the primary one several times: every species is—must be—a going concern, and going concerns must be conservative; most deviations from the time-tested tradition will be quickly punished by extinction. Eldredge himself (1989) has suggested that a major reason for stasis is "habitat tracking." Sterelny (1992, p. 45) describes it this way:

As the environment changes, organisms may react by tracking their old habitat. They might move north as the climate cools, rather than by evolv- ing adaptations to the cold. [This is not a mistake—Sterelny is a Southern Hemisphere philosopher of biology! ] Selection will usually drive tracking. For migrants that follow the habitat (personally or by reproductive dis- persion) will typically be fitter than the population fragment that fails to move, for the residual fragment will be less well adapted to the new environment and will be faced with new competition from other migrants tracking their old habitat.

Note that habitat tracking is as much a "strategy" of plants as of animals. Indeed, some of the clearest cases of speciation invoke this phenomenon. As the icecap recedes after an ice age, the range of some Northern Asian plant spreads to the north year after year, "following" the ice, and spreading east
and west as it goes, crossing in the Bering Strait region, and perhaps even encircling the globe like the herring gulls. Then, as the ice advances south during the next ice age, it sheers off the connections between the Asian and North American parts of the family, creating two isolated ranges that then naturally diverge into distinct species, but as they both move southward in their respective hemispheres, they continue to look much the same, because they track their favored climatic conditions, instead of staying put and going in for further winter adaptations.6

Another possible explanation of punctuated equilibrium is purely theoretical. Stuart Kauffman and his colleagues have produced computer models that exhibit behavior in which relatively long periods of stasis are interrupted by brief periods of change not triggered by any "outside" interference, so this pattern seems to be an endogenous or internal feature of the operation of particular sorts of evolutionary algorithms. (For a recent discussion, see Bak, Flyvbjerg, and Sneppen 1994.)

It is quite clear, then, that equilibrium is no more a problem for the neo-Darwinian than punctuation; it can be accounted for, and even predicted. But Gould has seen yet another revolution lurking in punctuated equilibrium. Maybe the horizontal steps of punctuation are not just (relatively) rapid steps in Design Space; maybe what is important about them is that they are steps of speciation. How could this make a difference? Look at figure 10.10.

In both cases, the lineage at K got where it got by exactly the same sequence of punctuations and equilibria, but the case illustrated on the left shows a single species undergoing rapid periods of change followed by long periods of stasis. Such change without speciation is known as anagenesis. The case illustrated on the right is an instance of cladogenesis, change via speciation. Gould claims that the rightward trend in the two cases would have a different explanation. But how could this be true? Recall what we learned in chapter 4: speciation is an event that can only be retrospectively identified. Nothing that happens during the sideways move could distinguish an anagenetic process from a cladogenetic process. There has been speciation only if there is a later flourishing of separate branches that survive long enough to be identifiable as separate species.

Couldn't there be special processes of what we might call hopeful speciation—or incipient speciation? Consider a case in which speciation does occur. Parent-species A splits into daughter-species B and C.

Now wind back the tape just far enough in time to drop a bomb (an asteroid, a tidal wave, a drought, poison) on the earliest members of the B species, as in the middle diagram. Doing this turns what had been a case of speciation into something indistinguishable from a case of anagenesis (on the right). The fact that the bomb prevents those whose offspring it kills

6. George Williams (1992, p. 130) disputes the importance of habitat tracking in stasis, noting that parasites, "seasonal amplitude of insolation" (amount of sunshine), and many other environmental factors would always be different after a geographical move, so that populations would never be able to stay in exactly the same selective environment, and hence would be subjected to selection pressure in spite of moving. But it seems to me that much if not all of the adjustment to these selection pressures could be invisible to paleontology, which can only see in the fossil record the preserved changes in hard-part design. Habitat tracking could be responsible for much of the paleontologically observable stasis (and what other stasis do we know about?), even if Williams is right that this body-plan stasis would have to mask concurrent nonstasis at most if not all other design levels in response to the many environmental changes that would have to accompany any long-range habitat-tracking moves. And unless many species moved in unison in their habitat tracking, there couldn't be habitat tracking at all, since other species are such crucial elements in any species' selective environment.
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from ever being grandparents could hardly make a difference to how their contemporaries got sorted out by selective pressure. That would require some sort of backward-in-time causation.

Is this really true? You may think that this would be true if the event that kicked off the speciation was a geographic split, guaranteeing the complete causal isolation of the two groups (allopatric speciation), but what if the speciation got under way within a population that formed two reproduc-tively incommunicative subgroups that competed directly against each other (in a form of sympatric speciation)? Darwin proposed, as we noted (see page 43), that competition between closely related forms would be a driving force in speciation, so the presence—the nonabsence—of what can be retrospectively identified as the first generations of a "rival" species might be very important indeed for speciation, but the fact that these rivals are "going to be" the founders of a new species could not play a role in the intensity or other features of the competition and hence in the speed or direction of the horizontal motion in Design Space.

We may well suppose that relatively rapid morphological change (sideways movement) is a normally necessary precondition for speciation. Rapidity of change is crucially affected by the size of the gene pool: large gene pools are conservative and tend to absorb innovation attempts without a trace. One way of making a large gene pool small is dividing it in two, and this may in fact be the most common sort of downsizing, but thereafter it makes no difference whether or not nature discards one of the halves (as in the middle graph in figure 10.11). It is the bottleneck of a diminished gene pool that permits the rapid motion, not the presence of two or more different bottlenecks. If there is speciation, then two whole species pass through their respective bottlenecks; if there is no speciation, then one whole species is pressed through a single bottleneck. So cladogenesis cannot involve a process during a punctuation period different from the process that occurs in anagenesis, because the difference between cladogenesis and anagenesis is definable only in terms of postpunctuation sequiae. Gould sometimes speaks as if speciation does make a difference. For instance, Gould and Eldredge (1993, p. 225) speak of "the crucial requirement of ancestral survival after punctuated branching" (as shown on the left in figure 10.11), but according to Eldredge (personal communication) this is only a crucial epistemological requirement for the theorist, who needs "ancestral survival" as evidence of descent.

His explanation is interesting. The fossil record is loaded with cases in which one form abruptly stops and another, quite different, form abruptly appears "in its place." Which of these are cases of swift sideways leaps of evolution, and which are cases of simple displacement due to sudden immigration of a rather distant relative? You can't tell. It is only when you can see what you take to be the parent species coexisting for a while with what you take to be its offspring that you can be quite sure that there is a direct path from the earlier form to the later form. As an epistemological point, this completely undercuts the claim that Gould has wanted to make: that most swift evolutionary change has been accomplished by speciation. For if, as Eldredge says, the fossil record usually shows abrupt shifts without any "ancestral survival after punctuated branching," and if there is no telling which of these are cases of punctuated anagenetic change (as opposed to immigration phenomena), then there is no way of telling from the fossil record whether speciation is a very frequent or very rare accompaniment of rapid morphological change.

There might still be another way of making sense of Gould's insistence that it is speciation, not mere adaptation, that makes the big difference in evolution. What if it turned out that some lineages go in for a lot of punctuation (and, in the process, produce lots of daughter species) and other lineages do not, and those that do not do so tend to die out? Neo-Darwinians usually assume that adaptations occur by the gradual transformation of the organisms in particular lineages, but "if lineages do not change by transformation, then long term trends in lineages can hardly be the result of their slow transformation" (Sterelny 1992, p. 48). This has long been considered an interesting possibility (in their original article, Eldredge and Gould discuss it very briefly, and credit Sewall Wright 1967 as one of its sources). Gould's version of the idea (e.g., 1982a) is that whole species don't get revised by the piecemeal redesign of their individual members; species are rather brittle, unchanging things; the shifts in Design Space happen (largely? often? always?) because of species extinction and species birth. This idea is what Gould and Eldredge (1993, p. 224) call "higher level sorting." It is sometimes known as species selection, or clade selection. It is hard to get clear about, but we have the equipment already at hand to clarify its central point. Remember bait-and-switch? Gould is in effect proposing a new application of this fundamental Darwinian idea: don't think that evolution makes adjustments in existing lineages; evolution throws away whole lineages, and lets other, different, lineages prosper. It looks as if there are adjustments to lineages over time, but what is really going on is bait-and-switch at the species level. The right level at which to look for evolutionary trends, he could then claim, is not the level of the gene, or the organism, but the whole species or clade. Instead of looking at the loss of particular genes from gene pools, or the differential death of particular genotypes within a whole species...
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7. For a similar criticism of Gould, see Ayala 1982. See also G. Williams 1992, pp. 53-54; Williams, who defines cladogenesis as the isolation, however short-lived, of any gene pool, also points out the triviality to evolutionary theory of short-term cladogenesis (pp. 98-100).
population, look at the differential extinction rate of whole species and the
differential "birth" rate of species—the rate at which a lineage can speciate
into daughter species.

This is an interesting idea, but it is not, as it first appears to be, a denial of
the orthodox claim that whole species undergo transformation via "phy-letic
gradualism." Let it be true, as Gould proposes, that some lineages spawn lots
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longer than the latter. Look at the trajectory through Design Space of each
surviving species. It, the whole species, is at any period of time either in
stasis or undergoing punctuated change, but that change itself is a "slow
transformation of a lineage," after all. It may be true that the best way of
seeing the long-term macroevolutionary pattern is to look for differences in
"lineage fecundity" instead of looking at the transformations in the individual
lineages. This is a powerful proposal worth taking seriously, but it neither
refutes nor supplants gradualism; it builds on it.8

(The level shift Gould proposes reminds me of the level shift between
hardware and software in computer science; the software level is the right
level at which to answer certain large-scale questions, but it does not cast any
doubt on the truth of the explanations of the same phenomena at the hardware
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since victors, on average, may secure their success by general superiority
in design. [Gould 1989b, p. 8.]

Gould does not like this image of the wedge. What is wrong with it? Well, it
invites ( he claims ) a belief in progress, but this invitation, we have already
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Global, long-term progress, amounting to the view that things in the biosphere
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is simply a mistake—a mistake no orthodox Darwinians fall for. What else
might be wrong with the image of the wedge? Gould speaks in the same
article ( p. 15 ) of "the plodding predictability of the wedge," and I suggest
that this is exactly what offends him in the image: like the ramp of
gradualism, it suggests a sort of predictable, mindless trudge up the slopes of
Design Space (see, e.g., Gould 1993d, ch. 21). The trouble with a wedge is
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4. TINKER TO EVERS TO CHANCE: THE BURGESS SHALE
DOUBLE-PLAY MYSTERY

Even today a good many distinguished minds seem unable to accept or
even understand that from a source of noise natural selection alone and
unaided could have drawn all the music of the biosphere. In effect
natural selection operates upon the products of chance and can feed
nowhere else; but it operates in a domain of very demanding conditions,
and from this domain chance is barred.

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But modern punctuationalism—especially in its application to the vagaries of human history—emphasizes the concept of contingency: the unpredictability of the nature of future stability, and the power of contemporary events and personalities to shape and direct the actual path taken among myriad possibilities.

—Stephen Jay Gould 1992b, p. 21

Gould speaks here not just of unpredictability but of the power of contemporary events and personalities to "shape and direct the actual path" of evolution. This echoes exactly the hope that drove James Mark Baldwin to discover the effect now named for him: somehow we have to get personalities—consciousness, intelligence, agency—back in the driver's seat. If we can just have contingency—radical contingency—this will give the mind some elbow room, so it can act, and be responsible for its own destiny, instead of being the mere effect of a mindless cascade of mechanical processes! This conclusion, I suggest, is Gould's ultimate destination, revealed in the paths he has most recently explored.

I mentioned in chapter 2 that the main conclusion of Gould's Wonderful Life: The Burgess Shale and the Nature of History (1989a) is that if the tape of life were rewound and played again and again, chances are mighty slim that we would ever appear again. There are three things about this conclusion that have baffled reviewers. First, why does he think it is so important? (According to the dust jacket, "In this masterwork Gould explains why the Burgess Shale is important in understanding this tape of our past and in shaping the way we ponder the riddle of existence and the awesome improbability of human evolution.") Second, exactly what is his conclusion—in effect, who does he mean by "we"? And, third, how does he think this conclusion (whichever one it is) follows from his fascinating discussion of the Burgess Shale, to which it seems almost entirely unrelated? We will work our way through these questions from third to second to first.\(^{10}\)

Thanks to Gould's book, the Burgess Shale, a mountaintop quarry in British Columbia, has now been elevated from being a site famous among paleontologists to the status of an international shrine of science, the birthplace of ... well, Something Really Important. The fossils found there date from the period known as the Cambrian Explosion, a time around six hundred million years ago when the multicellular organisms really took off, creating the palm branches of the Tree of Life of figure 4.1. Formed under peculiarly felicitous conditions, the fossils immortalized in the Burgess Shale are much more complete and three-dimensional than fossils usually are, and their classification by Charles Walcott early in this century was guided by his literal dissection of some of the fossils. He shoehorned the varieties he found into traditional phyla, and so matters stood (roughly) until the brilliant reinterpretations in the 1970s and 1980s by Harry Whittington, Derek Briggs, and Simon Conway Morris, who claimed that many of these creatures—and they are an astonishingly alien and extravagant lot—had been misclassified; they actually belonged to phyla that have no modern descendants at all, phyla never before imagined.

That is fascinating, but is it revolutionary? Gould (1989a, p. 136) certainly thinks so. "I believe that Whittington's reconstruction of Opabinia in 1975 will stand as one of the great documents in the history of human knowledge." His trio of heroes didn't put it that way (see, e.g., Conway Morris 1989), and their caution has proven to be prophetic; subsequent analyses have tempered some of their most radical reclassification claims after all (Briggs et al. 1989, Foote 1992, Gee 1992, Conway Morris 1992). If it weren't for the pedestal Gould had placed his heroes on, they wouldn't now seem to have fallen so far—the first step was a doozy, and they didn't even get to take the step for themselves.

But in any case, what was the revolutionary point that Gould thought was established by what we may have learned about these Cambrian creatures? The Burgess fauna appeared suddenly (and remember what that means to a geologist), and most of them vanished just as suddenly. This nongradual entrance and exit, Gould claims, demonstrates the fallacy of what he calls "the cone of increasing diversity," and he illustrates his claim with a remarkable pair of trees of life.

A picture is worth a thousand words, and Gould emphasizes again and again, with many illustrations, the power of iconography to mislead even the expert. Figure 10.12 is another example, and it is his own. On the top, he tells us, is the old false view, the cone of increasing diversity; on the bottom, the improved view of decimation and diversification. But notice that you can turn the bottom picture into a cone of increasing diversification by simply stretching the vertical scale. (Alternatively, you can turn the top picture into a new and approved icon of the bottom sort by squeezing the vertical scale down, in the style of standard punctuated-equilibrium diagrams—e.g., on the right in figure 10.6.) Since the vertical scale is arbitrary, Gould's diagrams don't illustrate any difference at all. The bottom half of his lower diagram perfectly illustrates a "cone of increasing diversity," and who knows whether the very next phase of activity in the top diagram would be a decimation that turned it into a replica of the bottom diagram. The cone of increasing diversity is obviously not a fallacy, if we measure diversity by the number of different species. Before there were a hundred species there were ten, and before there were ten there were two, and so

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But modern punctuationalism—especially in its application to the vagaries of human history—emphasizes the concept of contingency: the unpredictability of the nature of future stability, and the power of contemporary events and personalities to shape and direct the actual path taken among myriad possibilities.

—Stephen Jay Gould 1992b, p. 21

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The cone of increasing diversity. The false but still conventional iconography of the cone of increasing diversity, and the revised model of diversification and decimation, suggested by the proper reconstruction of the Burgess Shale. [Gould 1989a, p. 46.]

**Figure 10.12**

It must be, on every branch of the Tree of Life. Species go extinct all the time, and perhaps 99 percent of all the species that have ever existed are now extinct, so we must have plenty of decimation to balance off the diversification. The Burgess Shale's flourishing and demise may have been less gradual than that of other fauna, before or since, but that does not demonstrate anything radical about the shape of the Tree of Life.

Some say this misses Gould's point: "What is special about the spectacular diversity of the Burgess Shale fauna is that these weren't just new species, but whole new phyla! These were radically novel designs!" I trust this was never Gould's point, because if it was, it was an embarrassing fallacy of retrospective coronation; as we have already seen, all new phyla—are indeed, new kingdoms!—have to start out as mere new subvarieties and then become new species. The fact that from today's vantage point they appear to be early members of new phyla does not in itself make them special at all. They might be special, however, not because they were "going to be" the founders of new phyla, but because they were morphologically diverse in striking ways. The way for Gould to test this hypothesis would be, as Dawkins (1990) has said, to "take his ruler to the animals themselves, unprejudiced by modern preconceptions about 'fundamental body plans' and classification. The true index of how unalike two animals are is how unalike they actually are!" Such studies as have been done to date suggest, however, that in fact the Burgess Shale fauna, for all their peculiarity, exhibit no inexplicable or revolutionary morphological diversity after all (e.g., Conway Morris 1992, Gee 1992, McShea 1993).

The Burgess Shale fauna were, let us suppose (it is not really known), wiped out in one of the periodic mass extinctions that have visited the Earth. The dinosaurs, as we all know, succumbed to a later one, the Cretaceous Extinction (otherwise known as the extinction at the K-T boundary), probably triggered about sixty-five million years ago by the impact of a huge asteroid. Mass extinction strikes Gould as very important, and as a challenge to neo-Darwinism: "If punctuated equilibrium upset traditional expectations (and did it ever!), mass extinction is far worse" (Gould 1985, p. 242). Why? According to Gould, orthodoxy requires "extrapolationism," the doctrine that all evolutionary change is gradual and predictable: "But if mass extinctions are true breaks in continuity, if the slow building of adaptation in normal times does not extend into predicted success across mass extinction boundaries, then extrapolationism fails and adaptationism succumbs" (Gould 1992a, p. 53). This is just false, as I have pointed out:

I cannot see why any adaptationist would be so foolish as to endorse anything like "extrapolationism" in a form so "pure" as to deny the possibility or even likelihood that mass extinction would play a major role in pruning the tree of life, as Gould puts it. It has always been obvious that the most perfect dinosaur will succumb if a comet strikes its homeland with a force hundreds of times greater than all the hydrogen bombs ever made. [Dennett 1993b, p. 43.]

Gould responded (1993e) by quoting a passage from Darwin himself, clearly expressing extrapolationist views. So is adaptationism (today) committed to this hopeless implication? Here is one instance when Charles Darwin himself has to count as a straw man, now that neo-Darwinism has moved on. It is true that Darwin tended to insist, shortsightedly, on the gradual nature of all extinctions, but it has long been recognized by neo-Darwinians that this was due to his eagerness to distinguish his view from the
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fates? That would be an amazing—and definitely revolutionary—claim, es-
specially if Gould then extended it as a generalization, but he has no evidence
for such a strong claim, and backs away from it (p. 50):

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we have no idea how to identify or define them), but I suspect that [the
Lady Luck hypothesis] grasps a central truth about evolution. The Burgess
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So we are still stuck with a mystery about what Gould thinks is so special
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In fact almost all the major anatomical designs of organisms appear in one
great whoosh called the Cambrian Explosion about 600 million years ago.
You realize that a whoosh or an explosion in geological terms has a very
long fuse. It can take a couple of million years, but a couple of million years
in the line of billions is nothing. And that is not what that world of
necessary, predictable advance ought to look like [emphasis added].

Really? Consider a parallel. There you sit, on a rock in Wyoming, watch-
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minutes, and then, suddenly—whoosh!—a stream of boiling water shoots
more than thirty meters into the air. It's all over in a few seconds, and then
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So why do they call it Old Faithful? In fact, this geyser repeats itself once
every sixty-five minutes, on average, year in and year out. The "shape" of the
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conclusion by looking at the field of Artificial Life, but he never mentions the prospect. Why not? I don't know, but I do know Gould is not fond of computers, and to this day does not even use a computer for word-processing; that might have something to do with it.

A much more important clue, surely, is the fact that when you do rerun the tape of life, you find all sorts of evidence of repetition. We already knew that, of course, because convergent evolution is nature’s own way of replaying the tape. As Maynard Smith says:

In Gould’s “replay from the Cambrian” experiment, I would predict that many animals would evolve eyes, because eyes have in fact evolved many times, in many kinds of animal. I would bet that some would evolve powered flight, because flight has evolved four times, in two different phyla; but I would not be certain, because animals might never get out on the land. But I agree with Gould that one could not predict which phyla would survive and inherit the earth. [Maynard Smith 1992, p. 34]

Maynard Smith’s last point is a sly one: if convergent evolution reigns, it doesn’t make any difference which phyla inherit the earth, because of bait-and-switch! Combining bait-and-switch with convergent evolution, we get the orthodox conclusion that whichever lineage happens to survive will gravitate towards the Good Moves in Design Space, and the result will be hard to tell from the winner that would have been there if some different lineage had carried on. Consider the kiwi, for instance. It has evolved in New Zealand, where it didn’t have any mammals to compete with, and it has converged on an amazing number of mammalian features—basically, it’s a bird that pretends it’s a mammal. Gould himself has written about the kiwi and its remarkably large egg (in 1991b), but as Conway Morris points out in his review (1991, p. 6):

... there is something else about the kiwi that receives only passing mention, and that is the extraordinary convergence between kiwis and mammals. ... I am sure Gould would be the last to deny convergence, but surely it undermines much of his thesis of contingency.

Gould does not deny convergence—how could he?—but he does tend to ignore it. Why? Perhaps because, as Conway Morris says, it is the fatal weakness in his case for contingency. (See also Maynard Smith 1992, Dawkins 1990, Bickerton 1993)

So now we have an answer to our third question. The Burgess Shale fauna inspire Gould because he mistakenly thinks that they provide evidence for his thesis of “radical contingency.” They might illustrate the thesis—but we won’t know until we do the sort of research that Gould himself has ignored.

We have reached second base. Just what is Gould’s claim about contingency? He says (1990, p. 3) that “the most common misunderstanding of evolution, at least in lay culture,” is the idea that “our eventual appearance” is “somehow intrinsically inevitable and predictable within the confines of the theory.” Our appearance? What does that mean? There is a sliding scale on which Gould neglects to locate his claim about rewinding the tape. If by “us” he meant something very particular—Steve Gould and Dan Dennett, let’s say—then we wouldn’t need the hypothesis of mass extinction to persuade us how lucky we are to be alive; if our two moms had never met our respective dads, that would suffice to consign us both to Neverland, and of course the same counterfactual holds true of every human being alive today. Had such a sad misfortune befallen us, this would not mean, however, that our respective offices at Harvard and Tufts would be unoccupied. It would be astonishing if the Harvard occupant’s name in this counterfactual circumstance was “Gould,” and I wouldn’t bet that its occupant would know a lot about paleontology, would give lectures and publish articles and spend thousands of hours studying fauna (not flora—Gould’s office is in the Museum of Comparative Zoology). If, at the other extreme, by “us” Gould meant something very general, such as “air-breathing, land-inhabiting vertebrates,” he would probably be wrong, for the reasons Maynard Smith mentions. So we may well suppose he meant something intermediate, such as “intelligent, language-using, technology-inventing, culture-creating beings.” This is an interesting hypothesis. If it is true, then contrary to what many thinkers routinely suppose, the search for extra-terrestrial intelligence is as quixotic as the search for extra-terrestrial kangaroos—it happened once, here, but would probably never happen again. But Wonderful Life offers no evidence in its favor (Wright 1990); even if the decimations of the Burgess Shale fauna were random, whatever lineages happened to survive would, according to standard neo-Darwinian theory, proceed to grope towards the Good Tricks in Design Space.

We have answered our second question. We are finally ready to tackle first base: why would this thesis be of great importance, whichever way it came out? Gould thinks that the hypothesis of “radical contingency” will upset our equanimity, but why?

We talk about the “march from monad to man” (old-style language again) as though evolution followed continuous pathways of progress along unbroken lineages. Nothing could be further from reality. [Gould 1989b, P.14.]

What could not be further from reality? At first it might appear as if Gould was saying here that there is no continuous, unbroken lineage between the
conclusion by looking at the field of Artificial Life, but he never mentions the prospect. Why not? I don't know, but I do know Gould is not fond of computers, and to this day does not even use a computer for word-processing; that might have something to do with it.

A much more important clue, surely, is the fact that when you do rerun the tape of life, you find all sorts of evidence of repetition. We already knew that, of course, because convergent evolution is nature's own way of replaying the tape. As Maynard Smith says:

In Gould's "replay from the Cambrian" experiment, I would predict that many animals would evolve eyes, because eyes have in fact evolved many times, in many kinds of animal. I would bet that some would evolve powered flight, because flight has evolved four times, in two different phyla, but I would not be certain, because animals might never get out on the land. But I agree with Gould that one could not predict which phyla would survive and inherit the earth. [Maynard Smith 1992, p. 34]

Maynard Smith's last point is a sly one: if convergent evolution reigns, it doesn't make any difference which phyla inherit the earth, because of bait-and-switch! Combining bait-and-switch with convergent evolution, we get the orthodox conclusion that whichever lineage happens to survive will gravitate towards the Good Moves in Design Space, and the result will be hard to tell from the winner that would have been there if some different lineage had carried on. Consider the kiwi, for instance. It has evolved in New Zealand, where it didn't have any mammals to compete with, and it has converged on an amazing number of mammalian features—basically, it’s a bird that pretends it’s a mammal. Gould himself has written about the kiwi and its remarkably large egg (in 1991b), but as Conway Morris points out in his review (1991, p. 6):

... there is something else about the kiwi that receives only passing mention, and that is the extraordinary convergence between kiwis and mammals... I am sure Gould would be the last to deny convergence, but surely it undermines much of his thesis of contingency.

Gould does not deny convergence—how could he?—but he does tend to ignore it. Why? Perhaps because, as Conway Morris says, it is the fatal weakness in his case for contingency. (See also Maynard Smith 1992, Dawkins 1990, Bickerton 1993)

So now we have an answer to our third question. The Burgess Shale fauna inspire Gould because he mistakenly thinks that they provide evidence for his thesis of "radical contingency." They might illustrate the thesis—but we won’t know until we do the sort of research that Gould himself has ignored.

We have reached second base. Just what is Gould’s claim about contingency? He says (1990, p. 3) that "the most common misunderstanding of evolution, at least in lay culture," is the idea that "our eventual appearance" is somehow intrinsically inevitable and predictable within the confines of the theory. "Our appearance? What does that mean? There is a sliding scale on which Gould neglects to locate his claim about rewinding the tape. If by "us" he meant something very particular—Steve Gould and Dan Dennett, let’s say—then we wouldn't need the hypothesis of mass extinction to persuade us how lucky we are to be alive; if our two moms had never met our respective dads, that would suffice to consign us both to Neverland, and of course the same counterfactual holds true of every human being alive today. Had such a sad misfortune befallen us, this would not mean, however, that our respective offices at Harvard and Tufts would be unoccupied. It would be astonishing if the Harvard occupant's name in this counterfactual circumstance was "Gould," and I wouldn’t bet that its occupant would be a habitue of bowling alleys and Fenway Park, but I would bet that its occupant would know a lot about paleontology, would give lectures and publish articles and spend thousands of hours studying fauna (not flora—Gould's office is in the Museum of Comparative Zoology). If, at the other extreme, by "us" Gould meant something very general, such as "air-breathing, land-inhabiting vertebrates," he would probably be wrong, for the reasons Maynard Smith mentions. So we may well suppose he meant something intermediate, such as "intelligent, language-using, technology-inventing, culture-creating beings." This is an interesting hypothesis. If it is true, then contrary to what many thinkers routinely suppose, the search for extra-terrestrial intelligence is as quixotic as the search for extra-terrestrial kangaroos—it happened once, here, but would probably never happen again. But Wonderful Life offers no evidence in its favor (Wright 1990); even if the decimations of the Burgess Shale fauna were random, whatever lineages happened to survive would, according to standard neo-Darwinian theory, proceed to grope towards the Good Tricks in Design Space.

We have answered our second question. We are finally ready to tackle first base: why would this thesis be of great importance, whichever way it came out? Gould thinks that the hypothesis of "radical contingency" will upset our equanimity, but why?

We talk about the "march from monad to man" (old-style language again) as though evolution followed continuous pathways of progress along unbroken lineages. Nothing could be further from reality. [Gould 1989b, P-14]

What could not be further from reality? At first it might appear as if Gould was saying here that there is no continuous, unbroken lineage between the
"monads" and us, but surely there is. There is no more secure implication of Darwin's great idea than that. As I put it in chapter 8, it is not controversial that we are all direct descendants of macromonads—simple precellular replicators under one name or another. So what can Gould be saying here? Perhaps we are meant to put the emphasis on "pathways of progress"—it is the belief in progress that is so far from the truth. The pathways are continuous, unbroken lineages all right, but not lineages of global progress. This is true, but so what?

There aren't global pathways of progress, but there is incessant local improvement. This improvement seeks out the best designs with such great reliability that it can often be predicted by adaptationist reasoning. Replay the tape a thousand times, and the Good Tricks will be found again and again, by one lineage or another. Convergent evolution is not evidence of global progress, but it is overwhelmingly good evidence of the power of processes of natural selection. This is the power of the underlying algorithms, mindless all the way down, but, thanks to the cranes it has built along the way, wonderfully capable of discovery, recognition, and wise decision. There is no room, and no need, for skyhooks.

Can it be that Gould thinks his thesis of radical contingency would refute the core Darwinian idea that evolution is an algorithmic process? That is my tentative conclusion. Algorithms, in the popular imagination, are algorithms for producing a particular result. As I said in chapter 2, evolution can be an algorithm, and evolution can have produced us by an algorithmic process, without its being true that evolution is an algorithm for producing us. But if you didn't understand that point, you might think:

If we are not the predictable result of evolution, evolution cannot be an algorithmic process.

And then you would be strongly motivated to prove "radical contingency" if you wanted to show that evolution wasn't just an algorithmic process. It might not have recognizable skyhooks in it, but at least we'd know it wasn't all done with nothing but cranes.

Is it likely that Gould could be so confused about the nature of algorithms? As we shall see in chapter 15, Roger Penrose, one of the world's most distinguished mathematicians, wrote a major book (1989) on Turing machines, algorithms, and the impossibility of Artificial Intelligence, and his whole book is based on that confusion. This is not really such an implausible error, on either thinker's part. A person who really doesn't like Darwin's dangerous idea often finds it hard to get the idea in focus.

That concludes my Just So Story about how Stephen Jay Gould became the Boy Who Cried Wolf. A good adaptationist should not just rest content with a plausible story, however. At the very least, an effort should be made to consider, and rule out, alternative hypotheses. As I said at the outset, I am more interested in the reasons that have held the myth together than I am in the actual motives of the actual man, but it might seem disingenuous for me not even to mention the obvious "rival" explanations crying to be considered: politics and religion. (It could well be that there is a political or religious motivation behind the yearning for skyhooks I impede to him, but those would not be rival hypotheses; they would be elaborations of my interpretation, postponable to another occasion. Here I must briefly consider whether one of these—politics or religion—might offer a simpler, more straightforward interpretation of his campaigns, obviating my analysis. Many of Gould's critics have thought so; I think they are missing the more interesting possibility.)

Gould has never made a secret of his politics. He learned his Marxism from his father, he tells us, and until quite recently he was very vocal and active in left-wing politics. Many of his campaigns against specific scientists and specific schools of thought within science have been conducted in explicitly political—indeed, explicitly Marxist—terms, and have often had right-wing thinkers as their targets. Not surprisingly, his opponents and critics have often supposed, for instance, that his punctuationism was just his Marxist antipathy for reform playing itself out in biology. Reformers are the worst enemies of revolutionaries, as we all know. But that, I think, is only a superficially interesting possibility. After all, John Maynard Smith, his polar opposite in the evolution controversies, has a Marxist background as rich and active as Gould's, and there are others with left-wing sympathies against whom Gould has directed attacks. (And then there are all the ACLU liberals like myself, though I doubt if he knows or cares.) Following his return from a visit to Russia, Gould (1992b) drew attention, as often before, to the difference between the gradualness of reform and the suddenness of revolution. In this interesting piece, Gould (p. 14) reflects on his experiences in Russia, and the failure of Marxism there—"Yes, the Russian reality does discredit a specific Marxist economics"—but goes on to say that Marx has been proven right about "the validity of the larger model of punctuational change." That does not mean that, for Gould, Marx's economic and social theory was never the point, but it is not hard to believe that Gould would keep his attitudes about evolution on board while jettisoning some political baggage that had outlasted its welcome.

As for religion, my own interpretation is, in one important sense, a hypothesis about Gould's religious yearnings. I see his antipathy to Darwin's dangerous idea as fundamentally a desire to protect or restore the Mind-first, top-down vision of John Locke—at the very least to secure our place in the cosmos with a skyhook. (Secular Humanism is a religion for some, and they sometimes think that Humanity cannot be special enough to matter if it is the product of merely algorithmic processes, a theme I will explore in...
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Gould has often asserted that there is no conflict between evolutionary theory and religion.

Unless at least half my colleagues are dunces, there can be—on the most raw and empirical grounds—no conflict between science and religion. I know hundreds of scientists who share a conviction about the fact of evolution, and teach it in the same way. Among these people I note an entire spectrum of religious attitudes—from devout daily prayer and worship to resolute atheism. Either there’s no correlation between religious belief and confidence in evolution—or else half of these people are fools. [Gould 1987, p. 68.]

Some more realistic alternatives would be that those evolutionists who see no conflict between evolution and their religious beliefs have been careful not to look as closely as we have been looking, or else hold a religious view that gives God what we might call a merely ceremonial role to play (more on this in chapter 18). Or perhaps, with Gould, they are careful to delimit the presumed role of both science and religion. The compatibility that Gould sees between science and religion holds only so long as science knows its place and declines to address the big questions. "Science does not deal with questions of ultimate origins" (Gould 1991b, p. 450.). One way of interpreting Gould’s campaigns within biology over the years might be as an attempt to restrict evolutionary theory to a properly modest task, creating a *cordon sanitaire* between it and religion. He says, for instance:

Evolution, in fact, is not the study of origins at all. Even the more restricted (and scientifically permissible) question of life’s origin on our earth lies outside its domain. (This interesting problem, I suspect, falls primarily within the purview of chemistry and the physics of self-organizing systems.) Evolution studies the pathways and mechanisms of organic change following the origin of life. [Gould 1991b, p. 455.]

This would rule the entire topic of chapter 7 out of bounds to evolutionary theory, but, as we have seen, that has become the very foundation of Darwinian theory. Gould seems to think that he should discourage his fellow evolutionists from drawing grand philosophical conclusions from their work, but if so he has been trying to deny to others what he allows himself. In the concluding sentence of *Wonderful Life* (1989a, p. 323), Gould is ready to draw a fairly specific religious conclusion from his own consideration of the implications of paleontology:

We are the offspring of history, and must establish our own paths in this most diverse and interesting of conceivable universes—one indifferent to our suffering, and therefore offering us maximal freedom to thrive, or to fail, in our own chosen way.

Curiously enough, this strikes me as a fine expression of the implications of Darwin’s dangerous idea, not at all in conflict with the idea that evolution is an algorithmic process. It is certainly an opinion I wholeheartedly share. Gould, however, seems to think the view he is combating so vigorously is deterministic and ahistorical, in conflict with this creed of freedom. “Hyper-Darwinism,” Gould’s bogey, is simply the claim that no skyhooks are needed, at any point, to explain the upward trends of the branches of the Tree of Life. Like others before him, Gould has tried to show the existence of leaps, speed-ups, or other inexplicable trajectories—inexplicable by the tools of “hyper-Darwinism.” But however “radically contingent” those trajectories may have been, however “punctuated” the pace of travel has been, whether by non-Darwinian saltations or unfathomed “mechanisms of speciation,” this does not create any more elbow room for “the power of contemporary events and personalities to shape and direct the actual path taken among myriad possibilities.” No more elbow room was needed (Dennett 1984).

One striking effect of Gould’s campaign on contingency is that he ends up turning Nietzsche upside down. Nietzsche, you will recall, thought that nothing could be more terrifying, more world-shattering, than the thought that if you kept replaying the tape, it would all happen again and again—eternal recurrence, the sickest idea that anybody ever had. Nietzsche viewed his task as teaching people to say “Yes!” to this awful truth. Gould, on the other hand, thinks he must assuage the people’s terror when confronted with the denial of this idea, if you kept replaying the tape, it wouldn’t ever happen again! Are both propositions equally mind-boggling? Which is worse? Would it happen again and again, or never again? Well, Tinker might say, either it would or it wouldn’t, there’s no denying that—and in
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12. Philip Morrison has pointed out that if the proposition that there is other intelligent life in the universe is mind-boggling, so is its denial. There are no ho-hum truths of cosmology.
the truth is a mixture of both: a little bit of Chance, a little bit of Ever. That's Darwin's dangerous idea, like it or not.

CHAPTER 10: Gould's self-styled revolutions, against adaptationism, gradualism, and extrapolationism, and for "radical contingency," all evaporate, their good points already firmly incorporated into the modern synthesis, and their mistaken points dismissed. Darwin's dangerous idea emerges strengthened, its dominion over every corner of biology more secure than ever.

CHAPTER 11: A review of all the major charges that have been leveled at Darwin's dangerous idea reveals a few surprisingly harmless heresies, a few sources of serious confusion, and one deep but misguided fear: if Darwinism is true of us, what happens to our autonomy?

1. A CLUTCH OF HARMLESS HERESIES

/ find on re-reading it that the picture it presents is close to the one I would paint if I were to start afresh, and write a wholly new book.


Before turning in part III to an examination of Darwin's dangerous idea applied to humanity (and the humanities), let's pause to take stock of our survey of controversies within biology proper. Gould has spoken of the "hardening" of the modern synthesis, but also voiced his frustration about how the modern synthesis keeps shifting in front of his eyes, making it difficult to get off a good shot. Its defenders keep changing the story, co-opting revolutionaries by incorporating the good points they make into the synthesis. How secure is the modern synthesis—or its unnamed successor, if you think it has changed too much to keep its old title? Is the current embodiment of Darwinism too hard or too soft? Like Goldilocks' favorite bed, it has proven to be just right: hard where it had to be, and compliant about those issues that are open for further investigation and debate.

To get a good sense of what is hard and what is soft, we may stand back a bit and survey the whole field. Some people would still love to destroy the credentials of Darwin's dangerous idea, and we can help them by pointing to controversies on which they needn't waste their energies, since no matter how they come out, Darwin's idea will survive intact or strengthened. And then we can also point out those hard, fixed points which, if destroyed, would truly overthrow Darwinism—but they are fixed for good reasons, and are about as likely to budge as the Pyramids.

Let's consider first some tempting heresies that would not overthrow