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The Role of Theology in Current Evolutionary Reasoning

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Abstract. A remarkable but little studied aspect of current evolutionary theory is the use by many biologists and philosophers of theological arguments for evolution. These can be classed under two heads: imperfection arguments, in which some organic design is held to be inconsistent with God's perfection and wisdom, and homology arguments, in which some pattern of similarity is held to be inconsistent with God's freedom as an artificer. Evolutionists have long contended that the organic world falls short of what one might expect from an omnipotent and benevolent creator. Yet many of the same scientists who argue theologically for evolution are committed to the philosophical doctrine of methodological naturalism, which maintains that theology has no place in science. Furthermore, the arguments themselves are problematical, employing concepts that cannot perform the work required of them, or resting on unsupported conjectures about suboptimality. Evolutionary theorists should reconsider both the arguments and the influence of Darwinian theological metaphysics on their understanding of evolution.

Key words: natural theology, imperfection, suboptimality, homology, methodological naturalism, creationism, panda's thumb, pentadactyl limb, Stephen Jay Gould, Darwin's theology

Introduction

The theory of evolution was born in a turbulent embrace with theology, and it has yet to relinquish that embrace. By "the theory of evolution," I mean Darwin's theory of the common descent of all organisms via the natural selection of randomly arising variation. By "theology," I mean propositions about what God would (or should) have done in creating the world.

The embrace in question is dialectical. Suppose one wants, as Darwin did, to refute the view that organisms were specially created by God. Or suppose one wants (again, as Darwin did) to reform the practice and content of biology generally, by showing the creationists and natural theologians still in the room politely but firmly to the door. For those ends it is necessary, at least for a time, to take the creationists and natural theologians seriously. That is, it is

necessary to assign empirical content to propositions beginning "If God had created organisms . . . " Those propositions can then be compared with the evidence; the theological theory can be found wanting; and the creationists and theologians, banished from biology.

But in that dialectic all sorts of things can go awry. The reforming program may find that it is easiest to rid biology of theology by declaring the latter to be a lot of empty nonsense. Meanwhile, the empirical program is busy comparing the predictions of the theory of creation with the evidence, and declaring the predictions falsified. Eventually someone will notice that these programs are markedly incongruent with each other. As Sober (1993, p. 46) observes, many biologists

> have taken pains to point out how the hypothesis of evolution by natural selection makes predictions that differ dramatically from those that flow from the design hypothesis. . . . At the same time and often in the same book, some biologists and philosophers have pursued a quite different line of attack. They have argued that creationism is not a scientific hypothesis because it is untestable. . . . If creationism cannot be tested, then what was one doing when one emphasized the imperfection of nature? Surely it is not possible to test and find wanting a hypothesis that is, in fact, untestable.

Now evolutionary biologists might acknowledge this incongruity and yet wave it away. Creationism is either false or untestable? *Fascinating*. Let someone else sort it out.

We might ask those same biologists, however, to explain why they think evolution is *true*. This is a task they face regularly, if only for pedagogical reasons. Consider a well-known example. The giant panda (*Ailuropoda melanoleuca*) possesses a pseudothumb built from the radial sesamoid, a wrist bone. The panda uses this structure, somewhat clumsily in the eyes of certain observers, to manipulate its main food, bamboo. Odd structures like the panda's pseudothumb, argues Stephen Jay Gould, "are the primary proofs that evolution has occurred" (1991, p. 61), for

> If God had designed a beautiful machine to reflect his wisdom and power, surely he would not have used a collection of parts generally fashioned for other purposes. . . . Odd arrangements and funny solutions are the proof of evolution – paths that a sensible God would never tread but that a natural process, constrained by history, follows perforce (1980, pp. 20–21).

This passage, from Gould's essay on the panda's thumb, is an instance of what is frequently called the *imperfection argument* for evolution. God is an optimizing creator. This structure, and hence, organism, is imperfect. Therefore this organism evolved.

Consider another example. It is widely held that all organisms descended from a common ancestor because they share certain biochemical universals, such as the genetic code (Dawkins 1986, p. 270; Ridley 1986, pp. 119–20; Mayr 1991, p. 23). These molecular universals are generally regarded as a strong evolutionary prediction. As Douglas Futuyma puts it,

> The only possible reason for these chemical universalities is that living things got stuck with the first system that worked for them. Once the genetic code was established, no species was ever free to try a new one. A mutation that caused the nucleotide sequence UUU to code for glycine instead of phenylalanine would have messed up all the species' proteins (1983, p. 205).[1]

On the other hand (argues Mark Ridley, developing the same point), if "different species had all been created separately, we should be very surprised if they had all been built with exactly the same genetic code" (1985, p. 10). We should be very surprised – to supply the missing, but implied, premise – because a *freely acting creator* could have constructed many different codes:

> Where a Creator would have been free to use different biochemical building blocks, evolution was not free: the history of the earliest organisms determined everything that happened thereafter (Futuyma 1983, p. 205).

This is a molecular variant of the *homology argument* for evolution. The apparent uniformity of certain biological patterns, such as the genetic code, is inconsistent with the freedom of a creator to act as he wishes. Therefore those patterns evolved.

Arguments of both sorts are common in the recent evolutionary literature. They occur most often where a case for evolution is being made: in the introductory chapters of books on evolution, for instance; in popular or semi-popular essays and books; or, in polemical writings, against creationists and other doubters of evolution. The arguments are given as good reasons for thinking that evolution, and not some other theory, best explains the origin and diversity of life.

Now this is a problem of much greater interest. It is widely held that evolutionary theory partakes necessarily of *methodological naturalism*, according to which one cannot in *scientific* reasoning refer to "God," "the Creator," "creation" (understood as the act of a divine intelligence), or other theological concepts (Eldredge and Cracraft 1980, p. 3; Hoffman 1989, pp. 11–12; see also Holton 1993). But the arguments for evolution that we shall consider are formulated in theological terms, usually explicitly so – a practice plainly inconsistent with methodological naturalism. We aren't supposed to be able to *say* anything, scientifically speaking, about God. Whatever we claim to know about God may be true or false, considered theologically or philosophically,

but that knowledge isn't the stuff of scientific explanation. How, then, do so many evolutionary biologists speak with confidence about what God would or would not have done?

One can dismiss this problem impatiently. One might argue for example that methodological naturalism is philosophically sound, and necessary for the practice of science. Therefore a *theological* argument for evolution is strictly speaking a *non sequitur*, or an indiscriminate rhetorical lurch into theology.[2] Zoologist Steven Scadding, for instance, after finding the theological premise of the "vestigial organ" argument, concludes

> that presented in this way, the vestigial organ argument is essentially a theological rather than a scientific argument, since it is based on the supposed nature of the Creator (1981, p. 174).

The argument is "based on an assumption about the nature of God," Scadding observes, "and thus should have no place in a scientific presentation of evolution" (Scadding 1982, p. 173). One can be heedlessly scrupulous about method here, however, and force a great deal of evolutionary reasoning out of science. As Mayr (1964, p. xii) points out, Darwin himself

> was converted to his new ideas only after he had made numerous observations that were to him quite incompatible with creation. He felt strongly that he must establish this point decisively before his readers would be willing to listen to the evolutionary interpretation. Again and again, he describes phenomena that do not fit the creation theory.

That the phenomena do not fit the creation theory implies of course that they *might* have fit. As it happens, they do not, and thus the theory of creation in question is false. Methodological naturalism however holds that since "God's will" (for instance) is inscrutable to science, the truth or falsity of any theory of creation can never be known. Nonetheless, Darwin piled up phenomena that he thought were plainly inconsistent with "God's will" as usually conceived, and his arguments persuaded most of his peers.

Or one might try to justify theological arguments for evolution pragmatically, as devices for shutting up the creationists. The arguments are indeed theological, this justification holds, but only because of their peculiar context. The arguments take the logical form of *reductio ad absurdum*, where one assumes the truth of an opponent's premises provisionally to derive a contradiction from them. Terms like "God" and "the Creator" appear in the arguments because they were introduced first by creationists, in *their* arguments, into a cultural debate about the truth of evolution. "God" is the principal cause invoked in non-evolutionary theories, and such theories do have genuine observational consequences. "If theology presumes to speak of the natural, material world," argues evolutionary biologist Bruce Naylor

(1982, p. 94), "its statements become open to scientific examination and potential falsification." The panda's thumb, in other words, can be stuck in the eye of the creationists. As a polemical tool, therefore, theology is useful. But evolutionary theory *as a natural science* claims nothing for itself theologically. When the debate is over, the theology, borrowed for the evening's *reductio*, goes into the trash bin with the folded programs and coffee cups.

It's a plausible rejoinder. This pragmatic justification collapses completely, however, when one examines the actual context of many of the arguments. An encyclopedia article on the evidence for evolution (see below) might reasonably be expected to be a straightforward summary of the data; likewise, a textbook treatment of the same material. Why use a theological *reductio* in those contexts? The rhetorical setting is that of a lecture, not a debate. The creationists (one might say) have left the building.

But what we see as *the evidence* for evolution exists against an epistemological backdrop where theology of one form or another has always been present. The panda's thumb is a sign of history – i.e., of descent – only when one is certain that "a sensible God" (Gould 1980, p. 20) would not stoop directly to contrive such oddities. Among their possible histories, we can conceive that organisms might have been divinely created at some point in the past (Indeed, this is what creationists maintain). The road to naturalistic common descent passes through the refutation of that possible history. One needs a God with qualities, therefore: a causal entity from which predictions can be derived. Then one can get at the business of refutation.

That borrowed God may remain, however, after the theory in which he served a causal role is gone. Just such a God haunts evolutionary theory today. Biologists have accepted (more or less uncritically, I think) that in justifying evolution, saying what a creator would or would not have done is unproblematical.[3] For this practice, they have the example of the *Origin* itself, and indeed, Darwin's writings generally, where arguments of the sort at issue play an important role in the case for evolution (Gillespie 1979; Kitcher 1985). Yet biologists and philosophers should consider Darwin's theological metaphysics with the same careful gaze they have turned on (for instance) his speculations about heredity. When the case for evolution is made today, the theological and aesthetic criteria at work usually stem directly from Darwin – that is, from his theological metaphysics. In the last section, I speculate briefly about the influence of Darwinian metaphysics on current theory.

In what follows immediately, however, I look critically at a number of the received arguments for evolution, namely, those resting on unjustified theological assumptions. While the arguments are familiar, their fragility is still largely unappreciated.

The imperfection argument

In the *History of Creation*, Haeckel argued that "even if we knew absolutely nothing of the other phenomena of development, we should be obliged to believe in the truth of the Theory of Descent, solely on the ground of the existence of rudimentary organs" (1876, p. 291). Under the heading of "Dysteleology," Haeckel gathered a number of apparently useless or imperfect structures that, he argued, could be reconciled with the theory of creation only by "ludicrous" ad hoc conjectures. In stressing the evidential force of imperfection, Haeckel followed Darwin's lead. Darwin's language is never more bitter than when condemning the failed teleology of theories of creation, which impute imperfect organic design to the direct intent of a rational and benevolent creator (The argument itself is ancient, of course, with roots extending at least to Lucretius).

Imperfection arguments occur widely in the recent literature, in a variety of contexts (e.g., Jacob 1982; Sober 1984, pp. 175–76; Futuyma 1985, p. 6; Dawkins 1986, pp. 91–94; Burian 1986; Williams 1992, pp. 7, 72–76). Doubtless the most influential formulations, however, occur in Stephen Jay Gould's writings. Since many authors draw on Gould's formulations, I consider them here in detail.[4] I have emphasized key words and phrases.

> The theory of natural selection would never have replaced the doctrine of divine creation if *evident, admirable design* pervaded all organisms. Charles Darwin understood this, and he focused on features that would be out of place in a world constructed by *perfect wisdom*. . . . This principle remains true today. The best illustrations of adaptation by evolution are the ones that strike our intuition as *peculiar* or *bizarre* (1977, p. 91).
>
> *Odd arrangements* and *funny solutions* are the proof of evolution – paths that a sensible God would never tread but that a natural process, constrained by history, follows perforce (1980, pp. 20–21).
>
> Evolution lies exposed in the *imperfections* that record a history of descent. Why should a rat run, a bat fly, a porpoise swim, and I type this essay with structures built from the same bones unless we all inherited them from a common ancestor? *An engineer, starting from scratch, could design better limbs in each case* (1983, p. 258).
>
> But how can a scientist infer history from single objects?. . . . Darwin answers that we must look for *imperfections and oddities*, because any *perfection* in organic design or ecology obliterates the paths of history and *might have been created as we find it*. This principle of imperfection became Darwin's most common guide. . . . I like to call it the "panda principle" . . . (1986, p. 63).

It will be useful to formalize Gould's argument:

1. If *p* is an instance of organic design, then *p* was produced either by a wise creator, or by descent with modification (evolution).
2. If organic design *p* was produced by a wise creator, then *p* should be perfect (or exhibit no imperfections).
3. Organic design *p* is not perfect (or exhibits imperfections).

The conclusion follows that

∴ Organic design *p* was not produced by a wise creator, but by descent with modification.

Premises 1 and 2 are theological. Gould's terms for the creator, in the passages cited above and in other instances of this argument, include "a perfect engineer" (1977, p. 91), "a sensible God" (1980, pp. 20–21), "a rational agent" (1983, p. 164) and "a wise creator" (1983, p. 258). Premises 2 and 3 refer also to "perfection," and we may infer that Gould holds that humans can readily discern the presence or absence of perfection when they examine organic designs.

Some problems with the imperfection argument

The imperfection argument is popular and compelling. Each premise is attended, however, with difficulties.

> *If* p *is an instance of organic design, then* p *was produced either by a wise creator, or by descent with modification.*

Assume that the terms "wise creator," "perfection," and "imperfection" are unambiguous, that is, understood in the same way by all observers (assumptions at issue below). Even granting this, the first premise describes a false dichotomy. Consider Figure 1, from Ridley's (1985) *The Problems of Evolution.* Here, (a) depicts what Ridley calls "separate creation," (b) is Lamarckian transformism, and (c) is evolution, or common ancestry. Ridley formulates "separate creation" as stating "that species do not change and that there were as many origins of species as there have been species" (1985, p. 3). Now some creationists may defend this view, although Ridley cites no authority for this interpretation of "separate creation." Pattern (a) represents what I will term a *static* theory of creation, in which designs display (more or less exactly) the form in which they were created. One would be hard pressed to find any expression of that view in the creationist literature, whether recently or within the past several decades. Rather, one will find extended discussions of what I will term *dynamic* theories of creation – as represented, for instance, by Figure 2. Here, the terminal species are members of basic types, stemming from common ancestors which were themselves created. Considerable

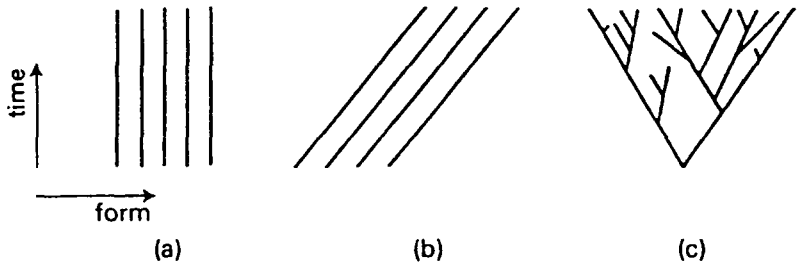

Figure 1. Three patterns of the history of life: (a) separate creation, (b) transformism, (c) evolution. In (a), species appear at the present very much as they were originally created, and "there were as many origins of species as there have been species" (Ridley 1985, p. 3; figure after Ridley 1985, p. 2).

– albeit ultimately bounded – change may have occurred between the creation of a design p and our observation of p. For instance, p may have speciated, or undergone genetic changes which gave rise to phenotypic modifications. In short, creationists defend the dynamic pattern of Figure 2, rather than Ridley's static pattern (Murris 1986; Landgren 1993; Scherer 1993).

The imperfection argument however presupposes a static theory, in which organisms appear today largely as they were originally created. Yet, as I have noted, few if any creationists defend that view. In fact, they argue that some designs are biologically "imperfect," but that such imperfection is consistent with their theory. Not all imperfections, therefore, count against creation, or a discontinuous geometry of organic form.

Consider blind cave animals. Futuyma asks, of the functionless lens and retina of the cave salamander, "Do we find evidence here of wise design?" (1983, p. 198). Yet in the same year that Futuyma posed his question, two well-known creationists, independently considering the same phenomenon, saw it as easily understood degenerative change:

> Blind cave fish with remnants of eyes ... appear to have true vestigial organs. These and similar degenerations apparently have indeed resulted from typically disadvantageous mutations. ... When hereditary changes are small enough to permit survival and reproduction, vestiges may remain. However, these vestigial structures at best are indicative of changes within limits; they are usually degenerative changes within a species (Frair and Davis 1983, p. 29).

So Futuyma's question has answers other than the one he presupposes. One may be able to explain the apparently poor design of the cave salamander's eye fairly easily within a dynamic theory of creation.

Consider another example, the rudimentary wings of flightless birds, which Naylor (1982, p. 93) regards as true vestigial structures whose existence

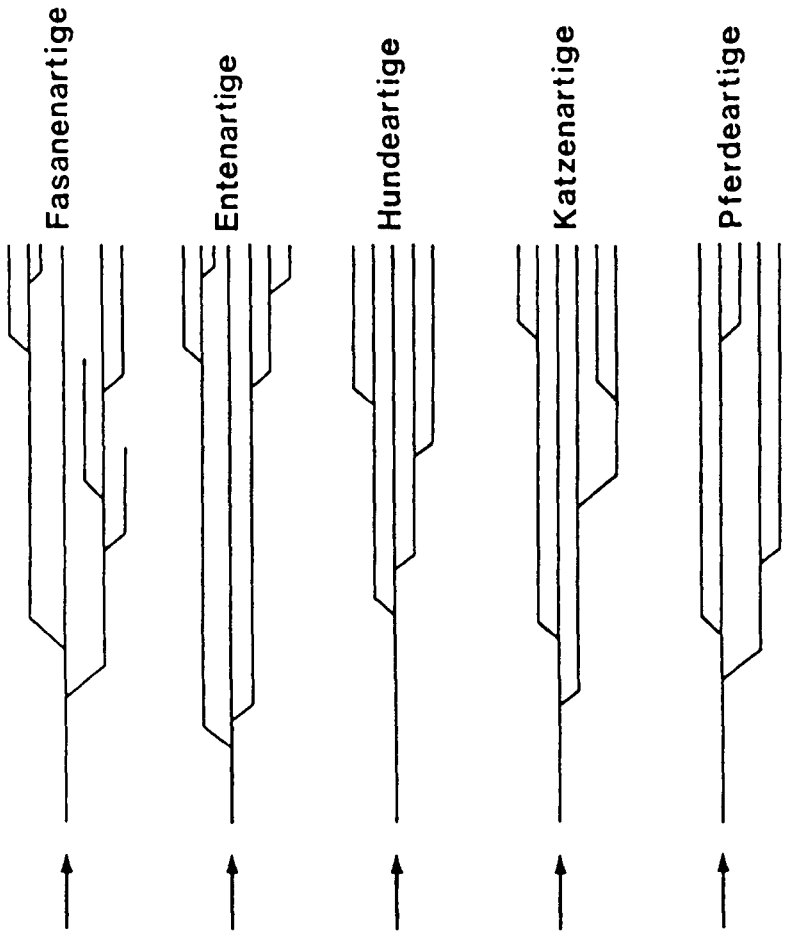

Figure 2. A "creation model" (after Junker and Scherer 1988, p. 16). The arrows in the figure depict the creation of various "ground types" [*Grundtypen*], which then vary within boundaries by microevolutionary processes. Note that the species observed at the present, within any ground type, may differ considerably from the originally created forms.

contradicts the theory of creation. The Dutch creationist Hendrik Murris (1986, pp. 200–201) argues however:

> Suppose that (as an oversimplified example) the allele 'A' imparts the ability to fly , while 'a' signifies flightlessness. If birds with AA and Aa combinations arrive and breed on an island where they have no natural enemies, the flightless aa individuals which will inevitably be hatched will survive. Some generations later, according to our model experiment, the entire population could be flightless!

Murris reasons that known population genetic processes may explain the origin of some, though not all, species of flightless birds. The German creationists Junker and Scherer similarly explain the origin of the rudimentary wings of flightless beetles and insects as cases of degenerative microevolution (1988, p. 126). In these dynamic theories, extant organic designs are the products not just of original creative intent, but also of the perturbing effects of natural causes, e.g., selection or drift (Darnbrough 1986, pp. 252–262). These causes must be separated from original design (if that analysis is possible).

By presupposing a static theory of creation, the first premise of the imperfection argument describes a false dichotomy. Of course, many supposedly imperfect organic designs, such as the human alimentary canal (Williams 1992, p. 7) or retina (Dawkins 1986, p. 93) cannot be explained by a dynamic theory of creation as degenerative changes. A dynamic theory can accommodate only certain limited neutral or degenerative changes without contradicting its tenet that variation is bounded. Most "vestigial" structures, for instance, appear to signify relationships expressly denied by even the most flexibly dynamic theories of creation. In any event, the imperfection argument need not, indeed should not, assume a static theory of creation. That it does so often presuppose such a theory, however, should alert us that the argument may rest on other doubtful assumptions.

> *If* p *was produced by a wise creator, then* p *should be perfect (or exhibit no imperfections).*

Here we come upon the major theological difficulties of the imperfection argument. Terms like "wise creator" must be fixed objectively, so that one knows (1) what a "wise creator" or a "sensible God" *is*, and (2) what a "wise creator" *would do*.

To illustrate the first problem, assume an imperfect organic design *p*. Then suppose (as John Stuart Mill believed) that the creator is benevolent and wise, but not omnipotent. This creator would not be able to avoid occasional design compromises. Some imperfections would necessarily be included in the creation – including, let us say, the imperfect organic design *p*. Here, the conclusion that imperfection of design is evidence of *descent* would not follow in every case. Gould writes that perfection alone cannot demonstrate descent, because "perfection need not have a history" (Gould 1980, p. 28). Given Mill's conception of the creator, however, imperfection need not have a history either. If a stapler that continually jams or a water pitcher with a dribbling spout were designed *de novo*, they have no history in any evolutionary sense – yet both artifacts are manifestly imperfect to anyone knowing their intended functions.

Mill's limited creator is of course heterodox (in the Christian tradition), and some may argue that one either defends the usual omnipotent conception of the creator, or one defends no conception at all. The point however, is that we have no grounds *within evolutionary theory itself* to exclude Mill's creator, or any one of a number of conceivable creators whose natures allow imperfection. The creator's place in the argument cannot be filled by just any conception. The conclusion *imperfection of organic design is evidence of descent* requires *logically* the conventional picture of an omnipotent and beneficent artificer (hereafter, the conventional conception). Far from being theologically neutral, therefore, the imperfection argument has a stake in the truth of a particular theology.

Consider next the problem of what a "wise creator" *would do*. According to the second premise, if a perfect God created the world, we should expect to observe "perfect" organic design – but what do we denote by this adjective? Might biological entities judged imperfect when considered individually combine to form a macrosystem judged perfect? Here, theological difficulties ordinarily ignored in any biological analysis come crowding forward. These difficulties can be avoided only by stipulation.

Take the question of the creator's *proper domain*. Many philosophers and theologians take the creator's proper domain to be the entirety of time and space, and furthermore hold that issues of moral value figure ultimately in any theory of creation. If this is so then the necessary finitude or limits of scientific observation may lead us to infer mistakenly that an organic design (e.g., the panda's thumb) is imperfect, when its imperfection is only *apparent*, that is, *local*. On this view, any judgment of perfection or imperfection must be qualified with a proviso that perfection – defined as divinely created perfection – can be judged only on the scale of the whole creation. And there is no reason for a creator to optimize one part of the universe at the expense of the whole. As one commentator writes:

> According to this view, what appears to be evil, when seen in isolation or in a too limited context, is a necessary element in a universe which, viewed as a totality, is wholly good. From the viewpoint of God, who sees timelessly and as a whole the entire moving panorama of created history, the universe is good . . . (Hick 1967, p. 137).

Several philosophers (notably Augustine and Leibniz) have articulated just such a global theodicy. In his *Theodicy*, Leibniz argued:

> [W]e acknowledge . . . that God does all the best possible, in accordance with the infinite wisdom which guides his actions. . . . But when we see some broken bone, some piece of animal's flesh, some sprig of a plant, there appears to be nothing but confusion, unless an excellent anatomist

> observe it: and even he would recognize nothing therein if he had not seen like pieces attached to their whole. It is the same with the government of God: that which we have been able to see hitherto is not a large enough piece for recognition of the beauty and order of the whole ([1710], 1985, pp. 206–207).

Although one may regard such a theodicy with scorn (see *Candide*), the problem remains: how do we judge divinely created perfection? Is it global or local? One can stipulate that only biological optimality matters, but the stipulation is arbitrary.

Organic design p *is not perfect (or exhibits imperfections).*

The terms "perfection" and "imperfection" have long been part of the descriptive vocabulary of natural history. Many authors use the terms with little apparent reflection, however, perhaps thinking that, as operational constructs in biology, "perfection" and "imperfection" are perspicuous. They are not. The epistemological difficulties that plague optimality arguments in evolutionary theory (Lewontin 1987) also occur in judgments of perfection (or imperfection). In the latter case, however, the difficulty of determining whether a state of a trait or organism is optimal *is magnified immeasurably by the theological context.*

The second premise says that a "wise creator" will create perfect organic designs. This seems clear enough until we come to cases, such as the panda. Gould argues that we can use optimality theory to designate "ideals for assessing natural departures" (1986, p. 66). It follows that in finding existing pandas to be imperfect, Gould must have some notion of an ideal panda, departure from which evokes a judgment of imperfection. So what is an ideal panda? That's rather hard to say, as Maynard Smith (1978, p. 32) has pointed out generally:

> It is clearly impossible to say what is the "best" phenotype unless one knows the range of possibilities. If there were no constraints on what is possible, the best phenotype would live for ever, would be impregnable to predators, would lay eggs at an infinite rate, and so on. It is therefore necessary to specify the set of possible phenotypes, or in some other way describe the limits on what can evolve.

With the imperfection argument, however, the question is not what can possibly evolve, but *what can possibly be created.* Given the conventional conception of the creator, there seem to be *no* limits on what is possible, nor any reason (short perhaps of logical contradiction) why one hypothetically possible panda should be preferred, as a counterfactual ideal, to another. If "perfection" is limited only by one's imagination, then specifying an ideal

phenotype, for the panda or any other organism, quickly becomes a fanciful exercise. Why couldn't the creator have given pandas the ability to fly?

We might then turn the problem around, and define a criterion of optimality that a "wise creator" ought to be able to achieve. Real organisms, if they were specially created, should then meet that criterion. The difficulty we hoped to escape, however, now returns in another form. We must now explain why, from all possible criteria, we have chosen one particular criterion (or set of criteria) for placing limits on the perfection expected of the creator. Just as within evolutionary theory, "a proper optimization theory must be capable of explaining why particular constraints on [phenotypic] accessibility are regarded as absolute while others are not" (Lewontin 1987, p. 156), so the imperfection argument must explain why the creator's designs should be constrained in certain instances but not in others. This is exceedingly difficult to do, and may be impossible.

Gould argues that the panda's thumb is "somewhat clumsy" and "wins no prizes in an engineer's derby" (Gould 1980, p. 24). Nevertheless, while watching pandas at the Washington zoo, he was "amazed at their dexterity, and wondered how the scion of a stock adapted for running could use its hands so adroitly" (Gould 1980, p. 21). Indeed, other observers *heap praise* on the panda's use of its forelimbs:

> The panda can handle bamboo stems with great precision, by holding them as if with forceps in the hairless groove connecting the pad of the first digit and pseudothumb. . . . When watching a panda eat leaves . . . we were always impressed by its dexterity. Forepaws and mouth work together with great precision, with great economy of motion . . . (Schaller, Jinchu, Wenshi, and Zing 1986, pp. 4, 48).

Although the panda's thumb may be suboptimal for many tasks, it does seem suited for what appears to be its usual function, manipulating bamboo. (At any rate the facts of the matter are very much in dispute.)

But even if the pseudothumb were suboptimal for manipulating bamboo, *it might still be the best structure possible.* The creator could have been bound by "compossibility" constraints, which would limit the design possibilities that are *mutually consistent.* One cannot, for instance, expect an electric clock designed to *obtain* its regularity from alternating current to be *more regular* than that current. The thumb may have some primary function for which it was designed, and the panda has co-opted it secondarily to strip bamboo. One may have failed to identify the correct reference situation by which to judge the design, perhaps by observing too little of the panda's life-history. The flippers of marine turtles, for example, strike us as badly designed for digging holes in beach sand to place eggs. The same flippers, however, perform efficiently

in the water, where the turtles spend most of their time. Which reference situation do we employ (Lewontin 1984, pp. 234–251)?

If the creator need only "act reasonably," that is, create designs which meet some specific criteria for optimality, then we must say why those (and not some other) criteria obtain if our suboptimality claims are to have any evidential force. This problem is made acute by the bothersome truth that any suboptimal design can be made optimal if we specify the right constraints (Lewontin 1987, pp. 158–159). How, then, do we specify criteria of optimality for an omnipotent creator?

A simple equation illustrates the problem. Suppose we define an optimal organism (design) as scoring 1.0, where the observed and expected design values in the following equation correspond exactly:

$$\frac{\text{observed design}}{\text{expected design}} = \text{optimality (suboptimality) measure}$$

Now suboptimality occurs when the numerator value falls below that of the denominator. If an optimal (created or ideal) panda has an expected design value of, say, 50, but actual pandas score 30, the panda as a species is suboptimal, suffering what we might call a *design shortfall*:

$$\frac{\text{actual (observed) pandas: 30}}{\text{optimal (expected) pandas: 50}} = 0.6 \text{ (}\textit{design shortfall of 0.4}\text{)}$$

We cannot solve this equation, however, without the expected design value. Absent the denominator, the equation has two unknowns and thus is unsolvable.[5] The expected design must be determined by optimality criteria, however, metrics along which design is measured. We have no such metrics for living things *as divinely created*. Thus we have no principled way of assigning the expected design value.

In summary, the premises of the imperfection argument provide a poor grounding at best for any empirical conclusions about the truth of evolution. Gould repeatedly uses the word "proof" for the imperfection argument (1977, p. 91; 1980, pp. 20–21; 1991, p. 61). That, it surely is not.

The homology argument

On opening any moderately advanced biology textbook nowadays one is likely to find, amid the discussion of the evidence for common descent, an illustration showing an array of tetrapod forelimbs (see Figure 3). The text will state that the pattern of similarity abstracted from the limbs (the *pentadactyl limb*) can be explained only by common descent. Francisco Ayala, for instance, is his *Encyclopedia Britannica* article on evolution (1988, p. 987) writes:

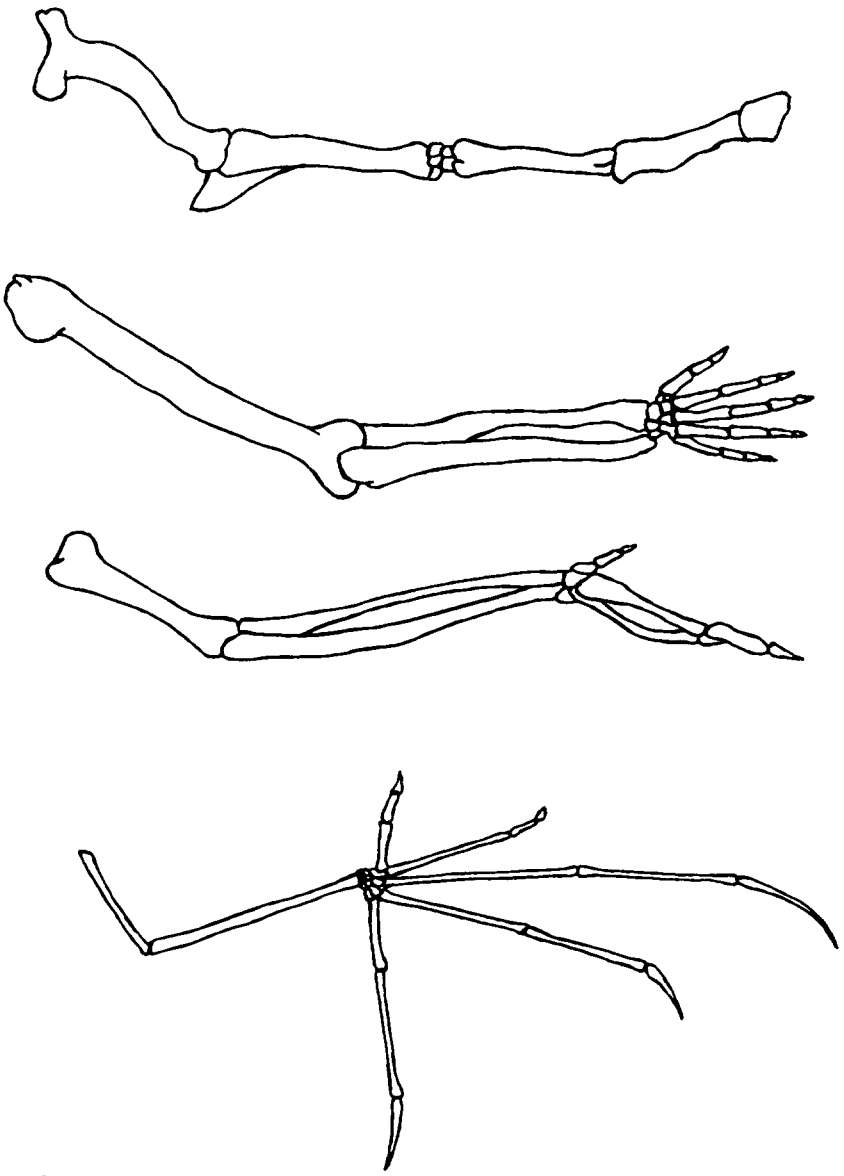

Figure 3. An array of vertebrate forelimbs. From top: horse, human, bird, and bat. (After Ayala 1988.)

From a purely practical point of view, it is incomprehensible that a turtle should swim, a horse run, a person write, and a bird or bat fly with structures built of the same bones. An engineer could design better limbs in each case. But if it is accepted that all of these skeletons inherited their

> structures from a common ancestor and became modified only as they adapted to different ways of life, the similarity of their structures makes sense.

"An engineer could design better limbs in each case" has the ring of an empirical finding. But the story is rather more complicated.

In Chapter XIII of the *Origin*, Darwin argued that it would be "hopeless" to explain the pentadactyl pattern "by utility or by the doctrine of final causes" (1859, p. 435). As Cain (1964, p. 44) observes, Darwin's view of these patterns is now canonical:

> Darwin ... originated the evolutionary interpretation which has been followed ever since, that the general plan of the pentadactyl limb is not now adaptive, although it must have been in the common ancestor, but its modifications are adaptive.

But how do we know that the general plan is suboptimal? This claim, after all, drives the inference to descent, or, to put it another way, makes implausible the inference to an optimizing designer. (A designer may have used the same pattern in different organisms precisely because that pattern is optimal for the functions in question.) What, then, grounds this seemingly empirical determination of suboptimality?

Here a brief historical excursus will be helpful. The patterns of homology employed by Darwin were familiar to pre-Darwinian anatomists, having been worked out by them in a non-evolutionary context. "Pre-Darwinian systematics did not profess an evolutionary explanation for homology," writes Ronald Brady (1985, p. 114), "but that privation did not prevent an extensive investigation of comparative anatomy, during which the principles of systematics were developed." Although the "unity of plan" of the tetrapod forelimb was powerfully suggestive of descent, and was so seen by some pre-Darwinians, descent was far from being the only plausible causal account available (Russell [1916] 1982, p. 214). The patterns of similarity evident among major groups of animals suggested similar functional requirements (Cuvier), non-material archetypes (Owen), or the plan of the Creator (Agassiz). Without transitional forms or a mechanism of functional transformation, non-material causes were genuinely competing explanations (Rieppel 1988, pp. 49–51).

Darwin made the patterns themselves the puzzle. Common descent would become the only reasonable explanation if Darwin's readers could be persuaded that, even without other "facts or arguments" (1859, p. 458) for descent, the theory explained patterns before which rival theories stood silent. But the rival theories – in particular, creation – must in fact stand silent, for if they also explained the patterns at hand, descent might remain only a plausible

but uncompelling theory, unable to claim broader explanatory promise than its rivals.

In the *Origin* (especially Chapter XIII), therefore, Darwin frames the patterns of comparative natural history in terms favorable to common descent, but uncongenial to any non-material explanation invoking design. In particular, one important avenue of explanation open to the creationist must be cut off, namely, the possibility that homologous patterns, such as the pentadactyl limb, are functionally optimal, and thus, could reasonably have been intended, and realized, by an optimizing creator.

For this task, Darwin finds a ready if unwitting ally in Owen.[6] "What could be more curious," asks Darwin, "than that the hand of a man, formed for grasping, that of a mole for digging, the leg of the horse, the paddle of the porpoise, and the wing of the bat, should all be constructed on the same pattern, and should include the same bones, in the same relative positions?" (1859, p. 434). Four of the five examples given – human hand, mole, horse, and bat – are Owen's, from *On the Nature of Limbs*. (Darwin substitutes a more familiar creature, the porpoise, for Owen's example of an aquatic mammal, the dugong.) It would be "hopeless," Darwin warns, to explain this pattern of similarity by functional utility: "The hopelessness of the attempt has been expressly admitted by Owen in his most interesting work on the 'Nature of Limbs' " (1859, p. 435).

Now it appears from Darwin's phrasing ("expressly admitted") that Owen, having failed to show that the pentadactyl pattern was functionally useful, was conceding as much. But this is "seriously misleading in one respect," Cain notes (1964, p. 44). "The hopelessness of the attempt is not what Owen was driven by the facts to *admit*, but what his whole lecture set out enthusiastically to *proclaim*." Owen was *keen to refute* the notion that the structures of organisms were specifically designed for their functions. He thus makes room for his "legitimate fruit of inductive research," namely, the "higher law of archetypal conformity" (1849, p. 70). In attacking the principle of specific design, and arguing for the constraints of archetypal homology, Owen cannot help supporting Darwin – who understandably then calls on him as an anatomical authority favoring descent, Owen's qualms about that the naturalistic version of that theory notwithstanding.

One will search *On the Nature of Limbs* in vain, however, for anything resembling an *empirical demonstration* that an homologous plan limits functionality, thus rendering an organism suboptimal. Owen's argument rests, rather, on an *a priori principle*:

> The teleologist would rather expect to find the same direct and purposive adaptation of the limb to its office as in the machine [devised by humans] (1849, p. 10).

Given some functional end, the human engineer "does not fetter himself by the trammels of any common type," says Owen, but uses whatever design is best suited:

> There is no community of plan or structure between the boat and the balloon, between Stephenson's locomotive engine and Brunel's tunneling machinery: a very remote analogy, if any, can be traced between the instruments devised by man to travel in the air and on the sea, through the earth or along its surface (1849, p. 10).

Yet when we consider organismal structures, Owen argues, a remarkable "unity of plan" is found – "so little to be expected, a priori":

> That every segment and almost every bone which is present in the human hand and arm should exist in the fin of the whale, solely because it is assumed that they were required in such number and collocation for the support and movements of that undivided and inflexible paddle, *squares ... little with our idea of the simplest mode of effecting the purpose ...* (1849, p. 40; emphasis added).

Richard Owen would have designed organisms differently. But of what evidential significance are *Richard Owen's ideas* about "the simplest mode of effecting the purpose"? We want to know if the structures of animals are well-suited to the functions they must perform: a question to be answered – if it can be answered at all – on the grounds, not of any "deep and pregnant" *a priori principle* (1849, p. 10), but by observation and experiment. As Cain argues,

> The fin of the dugong or whale may be of a simple external appearance when compared with the hand of Man, but it is not a simple stiff plate capable only of being waved up and down. The hoof of the horse may merely rest on the ground or beat upon it, and so be simpler than the hand of Man, but each hoof must be picked up and put down without the whole body being raised to correspond, or much energy will be wasted in an intolerably jerky gait. The hoof must adjust itself to some extent to the different angles at which the surface of the uneven ground may meet it, so that it does not slip, and yet it must bear a considerable weight – it cannot be as delicate as the sucker on the tube-foot of a starfish (1964, p. 43).

Owen never demonstrates that the various mammalian forelimbs he has examined, constructed on a common plan, are functionally less than optimal for being so constructed. Yet this is what Darwin takes away from Owen, and that, in turn, evolutionary biologists have taken away from Darwin. "An engineer could design better limbs in each case" (Ayala 1988, p. 987). *There is no evidence that this is true.*

What *does* ground the perception of suboptimality so widely shared among evolutionary biologists? Here, I would argue, strong theological preconceptions are at work. If the creator is *free to do as he pleases*, the appearance of plan can become the appearance of *limitation* or *constraint*, suggesting an unimaginative or even slavish repetition of structures along some predetermined pattern. "Intelligence and purpose," writes Neal Gillespie (1979, p. 71), interpreting Darwin's arguments against creation, "should be more creative than nature showed itself to be." This theological intuition – that the apparent uniformity of certain biological patterns is inconsistent with the freedom of a creator to act as he wishes – is nowhere better illustrated than in Darwin's book on orchids. After reviewing the homologies of orchids and ordinary flowers, Darwin appeals to our intuitions about *what God would have done in this case*:

> Can we feel satisfied by saying that each Orchid was created, exactly as we now see it, on a certain "ideal type;" that the omnipotent Creator, having fixed on one plan for the whole Order, did not depart from this plan; that he, therefore, made the same organ to perform diverse functions – often of trifling importance compared with their proper function – converted other organs into mere purposeless rudiments, and arranged all as if they had to stand separate, and then made them cohere? Is it not a more simple and intelligible view that all the Orchideae owe what they have in common, to descent from some monocotyledonous plant ... ([1877] 1984, pp. 245–246)?

Removing the theology from Darwin's argument for the common descent of the Orchideae would eviscerate it. Darwin provides no fossil evidence that orchids evolved from ordinary flowers, nor indeed any experimental evidence that such a transformation is even possible. Rather, Darwin describes patterns of similarity among orchids – which patterns might to a creationist indicate the purposeful workings of a designer. If one accepts, however, the premise that it is *unfitting* to ascribe variations on an "ideal type" to the direct artifice of an omnipotent creator, the same patterns become evidence of common descent. The theology in the passage is thus far more than a rhetorical device. It is the logical pivot of Darwin's entire argument.

In this vein, Futuyma (1985, p. 6) points out that flying vertebrates could have been designed otherwise than they are:

> An omnipotent creator could, as we can in imagination, create organisms with wings on their shoulders (e.g., angels, or the mythical Pegasus), but the wings of all flying vertebrates are modifications of the front legs of their ancestors.

How uncreative to have done things that way is the principal deliverance of this species of biological imagination. To be told that evidence suggests

nevertheless that the structures in question were created (i.e., are transformationally discrete, not derived materially from simpler forms) does not of course answer the question, "but why should they then appear to share the same plan?" One can imagine that organisms could have been constructed in any number of ways.

Here again speculation has free rein. Yet it precisely here that speculation is likeliest to mislead us. Surely the reason that homology is seen as evidence for descent is *not* because the phenomenon contradicts what one would expect a rational creator to do. An omnipotent creator could have made non-homologous vertebrate limbs, or different genetic codes, or indeed built organisms out of different types of matter entirely. These are not grounds to support an empirical claim about the causal history of homologous patterns. Suppose one argues, *contra* Darwin, that we have every reason for thinking a creator *would* have designed each species of orchid to show homologies with ordinary flowers. How, by everyday scientific methods, would one go about settling this dispute? One may assume or deny the truth of Darwin's particular theological aesthetic, but it is hard to see how that assumption is binding on other observers (or why we should take it as intelligible).

Many formulations of the homology argument, however, rest on similar theological assumptions. It is curious that in glossing the orchid arguments, Gould (1980) and other commentators (e.g., Ghiselin 1984) have not noticed this problem. Perhaps Darwin's theological aesthetic fits so closely with their own intuitions that its role in the argument escapes comment. Nevertheless, these theological assumptions need to be justified, or else it should be admitted that they stand as bare postulates. In analyzing Darwin's argument about homologies – in particular, his claim that a Creator would not use such patterns – Løvtrup (1987, p. 132) observes:

> Why not? Even the Creator may use a good device more than once. Yes, why not indeed? Darwin's arguments against this possibility are postulates, unfounded by any evidence.

If homology provides evidence for descent, it must do so *not* because homologies are inconsistent with what a rational creator would have done. A rational creator might have done any number of things. Rather, homologies appear to mark out a pathway of natural transformation characterizing a continuous geometry of organic form, i.e., of descent. Is the appearance of natural transformation more than an appearance? Is the geometry of nature profoundly continuous? These questions want empirical answers. Speculations about the freedom of the creator should be seen for what they are, and abandoned.

The influence of Darwinian metaphysics

Darwin's argument for descent with modification was pressed on many fronts – among them, the theological (Gillespie 1979; Brooke 1985; Cornell 1987; Kohn 1989). Darwin's corpus is permeated by a metaphysical program which was, Cornell (1987, pp. 384–385) argues, "more than useful rhetoric to Darwin, and more than a methodological convention that promoted science." Consider the notion of perfection:

> The assumption of perfect adaptation, which Darwin shared with most of the biologists of his generation, was derived from the belief that nature is a created, harmonious, and purposeful whole. . . . It is a natural, perhaps necessary, corollary of the belief that nature is a harmonious system preplanned in every detail by a wise and benevolent God (Ospovat 1980, pp. 189–190).

Cornell (1987, p. 396) concurs:

> The word "perfect" is an adjective generally reserved for divine action. That is how, for instance, Paley used it, and it was probably what Darwin understood, even when he was criticizing the belief in the perfection of particular forms . . . because that belief implied special creation by God.

Now, while Darwin came to reject the idea that organisms were perfectly designed for their environments, he never rejected the theoretical apparatus implied by the very terms "perfection" and "imperfection." Many arguments in the Origin make sense only if one presupposes the creator of early nineteenth century English natural theology – and Darwin does not challenge this conception. Rather, he turns to certain aspects of organic design which appear to fit only awkwardly into the usual schemes of natural theology, and drives these counterexamples back into the machinery of the argument from design. Instead of impiously attacking the nature or existence of the creator (as a skeptic, e.g., Aveling, might do), Darwin offers his theory of descent and secondary causes to explain what would otherwise be intolerable anomalies. *All this incongruity of design could not have been directly created.*

In so doing, of course, Darwin impales his creationist opponents on the horns of a dilemma. Either they deny the benevolence and wisdom of the creator, by making him the author of "abhorrent" designs, or they retain their conception of the creator, but must greatly circumscribe his actions, for if imperfect designs could be due to secondary causes, then could not many other (in fact, nearly all) organic structures be the products of secondary causes as well?

But note again that little indicates Darwin ever rejected the deep presuppositions which he inherited from English natural theology, namely, perfection

as an observable quality of organic design, and the conventional conception of the nature (if not the actions) of the creator. Indeed, a close reading of the Notebooks would suggest that Darwin saw his theory as providing a more sublime conception of the actions of the creator (see, for instance, D 36: "What a magnificent view one can take of the world . . . "). *Darwin employed a particular conception of God to judge theories of God's creative activity.* Otherwise, why should the multiple creations scornfully derided in D 37 as a "long succession of vile Molluscous animals" be beneath the "dignity" of God? Cornell (1987, p. 397) argues, of this and other passages from later notebooks:

> As always, Darwin's idea of "perfection" refers to the nice relationship of organisms to their physical surroundings. But it also refers to the overall design of the world, from a divine viewpoint. . . . Darwin's sense of a comprehensive system, the invocation of divine perfection, and his new theory are thus all closely related.

And, as Brooke (1985, p. 46) argues:

> The fact is that there are several entries in the transmutation notebooks which indicate that Darwin was discovering a philosophy of nature which he genuinely believed conferred a new grandeur on the deity, despite – or rather because of – the fact that it superseded Paley.

While current evolutionists may be indifferent or opposed to Darwin's theology, their use of the imperfection and homology arguments for evolution presupposes the intelligibility of notions rooted in Darwin's theological metaphysics: perfection as an observable quality of organic design, and the intuition at the heart of Darwin's metaphysics – that a rational and benevolent God would have created an organic world different from the one we observe. Both continue to inform evolutionary theory.[7]

Yet many hold that the Darwinian revolution entailed the surrender of theological speculation in biology (Mayr 1983, p. 25). Indeed, many scientists and philosophers would argue that natural science and theology view each other across a largely (if not completely) impassable epistemological gulf (Kolakowski 1982; Gilkey 1985). Science, on this view, is by its very nature committed to a thoroughgoing methodological naturalism. Hence, the problem which opened this essay: the persistence of Darwinian theological *themata* in evolutionary theory is inconsistent with the doctrine of methodological naturalism.

But should natural science necessarily be committed to methodological naturalism? The shortcomings of theological arguments for evolution may be evidence enough that science has no business meddling in theology (or vice versa). I draw a different moral, however. Science will have to deal with

theological problems if science is a truth-seeking enterprise; theology must confront the patterns of scientific experience if it hopes to speak to all of reality. What this essay helps to show, I think, is how very easy it will be to do both theology and science badly. That is not a brief for methodological naturalism, however. It is a tale of caution about how we should go about explaining the origin of the world's creatures.

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Notes

[1] Since 1985 several variant nuclear codes have been discovered, leading many workers to doubt the theory that once established the code must be invariant (Jukes and Osawa 1991).

[2] "Pure wind," a biologist called the arguments. "I never took Gould's suggestions seriously," a philosopher wrote, "that is, I never thought he meant me to take it seriously. If you find that philosophers or biologists do take the thing seriously I am profoundly disappointed in the intelligence of my colleagues." Most did take the arguments seriously. And, as pure wind, the arguments blow pretty steadily in many evolutionary biology textbooks.

[3] In the spring of 1979, I attended a series of lectures on evolution at the Carnegie Museum of Natural History, in Pittsburgh. The first lecture in the series was given by Leonard Krishtalka, a vertebrate paleontologist on the museum staff. For his opening illustration, Krishtalka had borrowed a peccary (a pig-like mammal) from the museum's collection, which he placed on the dais at the front of the auditorium. Pointing to the peccary's "dew claws" (so-called because these toes, on the rear of the limb just above the hoof, appear to touch only the "dewy" surface of the ground), Krishtalka asked, "Now why would God have created this animal with non-functional structures like the dew claw?" But of course God didn't create the peccary, he continued, natural selection did. What strikes me now about this illustration was how utterly clear its theological content seemed to Krishtalka, that is, as evidence supporting the causal story he was about to tell.

[4] Some readers argued that I ought not to cite Gould's general and semi-popular essays, on the grounds that the essays *were* general and semi-popular. The more I thought about this argument, however, the odder it seemed. The argument means either (a) Gould has knowingly misrepresented evolutionary theory to his lay readers, or (b) in presenting evolutionary theory to his lay readers, Gould has used language so "analogous, rhetorical, sometimes imprecise" (to quote one of my correspondents) that he has – despite his best intentions – misrepresented evolutionary theory. Those who make this argument can hardly have meant (a), but is (b) any more credible? On the topic of biological imperfection, Gould's popular (and technical) writings are strikingly consistent. It is hard to believe that a scientist renowned for his prose abilities would explain his own theory so poorly that he could, for more than a decade, continually mislead his readers. And Gould takes his popular writing far more seriously than

many of his colleagues. "The concepts of science, in all their richness and ambiguity," he argues, "can be presented without any compromise, without any simplification counting as distortion, in language accessible to all intelligent people" (1989, p. 16). The reading list for Gould's introductory science course at Harvard (Science B–16) includes, out of a total of 62 readings, 33 of his essays from *Natural History* magazine.

[5] Gabriel Nelson pointed this out to me.

[6] In the section of Chapter XIII headed "Morphology," only two authors are cited by name: Geoffroy St. Hilaire (once) and Owen (four times).

[7] Some have urged me to note that Gould, like many (most?) evolutionary theorists, is himself an agnostic, or, as Gould has put it, a "nontheist." Jeffrey Levinton observed that Gould "is about as 'theological' as anyone calling himself an atheist." True, and immaterial. The theological convictions of a person have no bearing on the truth or falsity of the propositions, theological or otherwise, that he puts forward publicly as worthy of assent.

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