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God, Gould, and the Panda's Thumb

Stephen Dilley

Discovery Institute, Seattle, WA 98104, USA; sdilley@discovery.org

Abstract: The panda's thumb argument, championed by the late Stephen Jay Gould, stands as one of the most famous polemics for common ancestry. In this essay, I analyze Gould's argument in several steps. First, I attempt to reconstruct the argument in both deductive and likelihood formulations. I contend that both versions of the argument rest on a theological claim—namely, that God would not (likely) create or allow a suboptimal panda's thumb. I then argue that a wide range of people are not rationally obligated to accept this theological claim. Next, I give special attention to the likelihood formulation's emphasis on a contrastive argument for evolution over special creation. I contend that a great number of people are not rationally obligated to accept this formulation either. I next consider and reply to an objection that Gould never intended the panda argument as an apologetic for evolution (and an attack on special creation) but rather as a critique of adaptationism. Finally, I argue that the panda argument conflicts with Gould's broader views about the human mind and the relationship between theology and science. I also note along the way that the shortcomings of the panda argument apply to a number of other arguments for evolutionary theory. To be sure, I do not criticize evolution itself or the comprehensive grounds for it. Instead, my primary aims are to analyze the panda argument and suggest that caution is in order about similar arguments as well.

Keywords: Stephen Jay Gould; theology; evolutionary theory; common ancestry; panda's thumb; suboptimality; dysteleology; science and religion; special creation

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1. Introduction

Stephen Jay Gould was a towering, if controversial, figure in late 20th century evolutionary biology. Before he passed away in 2002 at age 60, his influence extended deeply into the professional guild and the public square. By the end of his career, he had published roughly 480 peer-reviewed papers, two dozen books, 300 essays, and 100 book reviews (Shermer 2002). As a skilled essayist, he arguably stood among the ranks of T.H. Huxley and J.B.S. Haldane. And his professional accomplishments were recognized with the highest honors, including the Linnean Society of London's Darwin–Wallace Medal, the Paleontological Society Medal, the MacArthur Fellowship, the Phi Beta Kappa Award in Science (twice), and others. In 2000, the U.S. Library of Congress deemed him a "Living Legend".

Whatever one makes of Gould's array of controversial claims,[1] his most famous argument for evolution—derived from the panda's thumb—has become something of an icon in its own right (e.g., Salesa et al. 2006, p. 381; Prothero 2007, pp. 37–38; Dawkins 1986, p. 91; Rice 2007, p. 2; Futuyma 2013, pp. 613–14).[2] Perhaps this is not surprising, given that Gould championed this argument for over twenty years, from his *Natural History* column in 1978 to his *magnum opus* in 2002 (Gould 1978, 1980, 2002). Of all his arguments for evolution based on a single structure, he considered this one the *summum bonum*, the best of the best (Gould 1980, pp. 28–29; 1991, p. 61; 2002, p. 104, 111–16).

In this essay, I analyze Gould's panda argument in several steps.[3] First, I attempt to reconstruct the argument in both deductive and likelihood formulations. I argue that both versions rely on God-talk. In particular, they hold that the Almighty would not (likely) create or allow a suboptimal panda's thumb. I canvass an array of worldviews

and claim that people who hold these views are not rationally obligated to accept this theological claim. Next, I give special attention to the likelihood formulation's emphasis on a contrastive argument for evolution over special creation. I likewise contend that a great number of people are not rationally obligated to accept this formulation either. I then consider the objection that Gould never intended the panda argument as an apologetic for evolution (and an attack on special creation) but rather as a critique of adaptationism. I argue that there are strong grounds, including textual grounds, to defuse this criticism. Finally, I argue that there are further reasons to reject the panda argument: it conflicts with Gould's broader views, including his doctrine of NOMA and his beliefs about the origin (and lack of design) of human cognition. Insofar as a person accepts these broader views, such a person has additional reasons to set aside the panda argument.

I also note along the way that problems with the panda argument apply to a number of other arguments for evolutionary theory. This is not to say that there is anything wrong with evolution in general or with the comprehensive case for it per se. Not all the grounds for evolution include God-talk, and such grounds are beyond the scope of this article.[4] Nonetheless, like Gould, a number of prominent biologists *do* offer theology-laden arguments for evolution, sometimes as their self-reported best stand-alone argument for the theory. These luminaries include Theodosius Dobzhansky, Niles Eldredge, Douglas Futuyma, Francisco Ayala, Jerry Coyne, Émile Zuckerkandl, Richard Dawkins, George Williams, Francis Collins, Kenneth Miller, and others. Their theology-laden arguments surface in major areas: molecular homology, embryology, biogeography, paleontology, gross anatomy, dysteleology, organic diversity, and the like. At least some of my criticisms of Gould's argument apply to others' arguments, *mutatis mutandis*[5] (Alexander 2014, pp. 234–51; Avise 2010; Ayala 2006, pp. 25–42, 71 85–89, esp. 34–36; 2007, pp. x–xi, 1–6, 22–23, 76, 88–92, 154–60; Barbour 2000, pp. 111–14; Collins 2006, pp. 130, 134–37, 139, see also pp. 176–77, 191, 193–94; Coyne 2009, pp. 12, 13, 18, 54–58, 64, 71–72, 81–85, 96, 101, 108, 121, 148, 161; Dawkins 1986, p. 93; 1995, pp. 95–133, esp. 105; 2009, pp. 270, 297, 332, 341, 351, 354, 356, 362, 364, 369, 371, 375, 388–89, 390–96; de Beer 1964, pp. 46–48, 55, elliptically; Dilley 2012, 2013, 2017; Diogo and Molnar 2016; Dobzhansky 1973; Eldredge 2000, pp. 99–100, 144–46; Forterre and Gadelle 2009; Futuyma 1995, pp. 46–50, 121–31, 197–201, 205, Futuyma 2013, pp. 53–54, 631–56, esp. 636–41; Gould 1977, pp. 91–96, esp. 91; 1980, pp. 20–21, 24, 28–29, 248; 1983, pp. 258–59, 384; 1986, pp. 60–69, esp. 63; Giberson and Collins 2011, pp. 34, 38, 55, 101–108, 161; Hunter 2001, 2007, 2014, 2019, 2020, 2021a, 2021b; Kitcher 1982, pp. 137–39; 2007, pp. 48–50, 57–58, 123–31; Kutschera 2007, pp. 90–91; Lents 2018; Lustig 2004; Mayr 2001; Miller 1999, pp. 80, 100–103, 267–69; Nelson 1996, pp. 12–39, esp. 31–34; cf. Numbers 2003; Pievani 2022; Prothero 2007, pp. 37–39; Radick 2005, p. 455; Shermer 2006, pp. 17–19, 42–44; Shubin 2008, pp. 173–98, elliptically; Wells 2010, pp. 67–88; Williams 1997, pp. 2, 4, 6–10, 104, 132–60; Zuckerkandl 2006, p. 10).[6]

2. Definitions

Before attending to the panda argument itself, some clarifications are in order. By 'evolution', I mean 'common ancestry', the view that all flora and fauna are the physical descendants of one (or a few) life forms that lived long ago. The term 'creationism' will primarily refer to contemporary young-earth creationism, the most prominent version of creationism in Gould's era. But because Gould also rejected intelligent design theory, I will also use the broader term 'contemporary design-based views' (or similar) to include not just contemporary young-earth creationism but also old-earth creationism as well as intelligent design theory. By contrast, I will use the term 'special creation' to refer narrowly to a version of creationism in which God is said to have created the structures and organs of each species well-matched to their respective environments.[7] (Readers should note that this term can have different meanings in other contexts.)

By 'theology', I mean propositions about a divine being. To be sure, I do not claim per se that Gould personally accepted the theological claims contained in the panda argument (although it is reasonable to think he did). Strictly speaking, Gould's personal beliefs are

irrelevant for present purposes. Instead, the present aim is to assess the panda *argument*. Doing so requires analyzing the theological (and non-theological) propositions in the argument and their justification. The truth or falsity of a proposition, like the soundness of an argument, stands or falls on its own. Thus, even when I use the phrase "Gould's theology", I simply mean his use of theology, regardless of what he personally believed. The same can be said of other thinkers who also use theology as part of their justification of evolutionary theory, *mutatis mutandis*.

In addition, I call attention to another feature of the God-talk in play. As mentioned, while Gould attacks 'special creation' (as I use the term), he also regards the panda argument as adjudicating between evolution and other design-based rivals. As I will argue below, however, these rivals do not necessarily hold the same view of God as 'special creation' does. With respect to these rivals, then, I argue that Gould uses what we may call "*positiva* theology" (Dilley 2012).[8] This theology tries to establish evolution and refute design rivals by drawing upon theology that is, in some sense, foreign to these rivals. If my argument is correct, Gould's contemporary adversaries are not rationally obligated to accept his partisan theology.[9]

A final preliminary, in the form of an objection, deserves a brief examination. A critic might say that Gould's interest in the panda's thumb and in suboptimality generally is actually a thinly veiled means of establishing exaptation and attacking adaptationism. Accordingly, it would be a mistake to hold that Gould's purpose for the panda argument is to support common ancestry and undermine creationism. I address this thoughtful objection later in the article. For the time being, I will proceed with my interpretation of Gould but will return to this point in due course.

3. The Panda's Thumb Argument

Now to the argument itself. While Gould's comprehensive defense of evolution includes many threads, at times he highlights imperfections as offering "the primary proofs that evolution has occurred" (Gould 1977, pp. 90–91; 1980, p. 13; 1983, pp. 55; see also pp. 131, 160, 258; 1991, p. 61). Of the many examples of imperfection Gould cites, he regards the panda's thumb as his "favorite" (Gould 1986, p. 210; 1991, pp. 66–67; 2002, p. 104). Gould's seminal essay, "The Panda's Thumb" and its companion "Senseless Signs of History", both published in the collection *The Panda's Thumb* (Gould 1980), provide the clearest exposition of the argument. Gould lays the initial groundwork in the title essay, framing the argument as a natural extension of Darwin's own emphasis on imperfections in the case for evolution. For Gould, Darwin's (1862) *On Orchids* exemplified this approach by detailing how orchids accomplish cross-pollination by using "jury-rigged" rather than ideal structures. Gould explains that orchids:

> evolved an astonishing variety of "contrivances" to attract insects, guarantee that sticky pollen adheres to their visitor, and ensure that the attached pollen comes in contact with female parts of the next orchid visited by the insect. . . . Orchids manufacture their intricate devices from the common components of ordinary flowers, parts usually fitted for very different functions. 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. Orchids were not made by an ideal engineer; they are jury-rigged from a limited set of available components. Thus, they must have evolved from ordinary flowers. (Gould 1980, p. 20)

Note the evident theology: "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". God would not borrow parts that He had originally created for other functions; instead, He would manufacture novel parts for new purposes. Accordingly, orchids "were not made by an ideal engineer"—they are far too "jury-rigged" for that. Moreover, these theological claims immediately lead to Gould's conclusion in the next

sentence: "Thus, [orchids] must have evolved from ordinary flowers". Gould's convictions about the Almighty provide *direct* grounds for evolution.

On Gould's view, Darwin's theology-laden argument about orchids illustrates the more general insight that the oddities of nature—whatever they are—serve as prime evidence for evolution. As Gould explains in the next paragraph:

> Our textbooks like to illustrate evolution with examples of optimal design—nearly perfect mimicry of a dead leaf by a butterfly or of a poisonous species by a palatable relative. But ideal design is a lousy argument for evolution, for it mimics the postulated action of an omnipotent creator. 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. (Gould 1980, pp. 20–21)

Gould writes that "ideal design" (or "optimal design") makes "a lousy argument for evolution". (Hereafter, I will use the terms "optimal design" and "ideal design" interchangeably.) According to Gould, optimal design is exactly what one would expect of an "omnipotent creator" or "sensible God". If the Almighty does anything at all, He does it well. As such, Gould believes that optimal designs provide virtually no evidence for evolution. Hence, evidence will have to come from the opposite quarter—from 'suboptimal' designs, which Gould calls "[o]dd arrangements and funny solutions". As he explains at length in "Senseless Signs of History", the companion essay to "The Panda's Thumb":

> Scientists who study history. . . must use inferential rather than experimental methods. They must examine *modern results* of historical processes and try to reconstruct the path leading from ancestral to contemporary words, organisms, or landforms. . . . But how can we infer pathways from modern results?... How do we know that a modern result is the product of alteration through history and not an immutable part of a changeless universe?
>
> This is the problem Darwin faced, for his creationist opponents did view each species as unaltered from its initial formation. How did Darwin prove that modern species are the products of history? We might suppose that he looked toward the most impressive results of evolution, the complex and perfected adaptations of organisms to their environments: the butterfly passing for a dead leaf, the bittern for a branch, the superb engineering of a gull aloft or a tuna in the sea.
>
> Paradoxically, he did just the opposite. He searched for oddities and imperfections. The gull may be a marvel of design; if one believes in evolution beforehand, then the engineering of its wing reflects the shaping power of natural selection. But you cannot demonstrate evolution with perfection because perfection need not have a history. After all, perfection of organic design had long been the favorite argument of creationists, who saw in consummate engineering the direct hand of a divine architect. A bird's wing, as an aerodynamic marvel, might have been created exactly as we find it today.
>
> But, Darwin reasoned, if organisms have a history, then ancestral stages should leave *remnants* behind. Remnants of the past that don't make sense in present terms—the useless, the odd, the peculiar, the incongruous—are the signs of history. They supply proof that the world was not made in its present form. When history perfects, it covers its own tracks. (Gould 1980, p. 28, original emphasis)

Present-day oddities count as evidence for evolution because they are *expected* given evolution but *unexpected* given divine design. Evolution operates by historical contingency, cobbling together new form and function from available parts; this process sometimes produces useless and peculiar structures. By contrast, if a "divine architect" had made the world "in its present form", organs and structures would be perfectly suited for an

organism's current functional needs in its specific environment. Gould's argument is clearly comparative: either evolution or divine design. He attacks the latter as part of his attempt to establish the former.

But just what kind of creative deity does Gould criticize? Three features stand out. First, as mentioned, Gould thinks that God would create perfect (or optimal) designs. More than half a dozen times in the excerpt above, Gould associates "perfection" (or its cousins) with the deity's handiwork.

Perfect for what? This question leads directly to the second feature of God's creative activity: adaptation. Organisms are well suited to their habitat. The hallmarks of divine designs are "complex and perfected adaptations of organisms to their environments" including "the butterfly passing for a dead leaf, the bittern for a branch, the superb engineering of a gull aloft or a tuna in the sea". Perfectly designed organisms tightly correspond to their habitat. Their individual features successfully fulfill particular functions required by an organism situated in a specific environment. Suboptimal designs, as Gould says elsewhere, are "departures" from this fit (Gould 1986, pp. 60–68, esp. 66). An optimally designed wing enables a bird to fly; a poorly designed wing does not. Thus, on this view, God would create organisms with features that perfectly fulfill their biological functions, enabling the organism to thrive in its particular habitat.

Third, the Almighty would create organisms matched to their *present-day* environment. According to Gould, 19th century creationists held that "each species [was] unaltered from its initial formation". Following their lead, Gould invokes a similar notion in his imperfection argument. A bird's wing, he says, might have been "created exactly as we find it today". Thus, in making his case for evolution, Gould says scientists must examine "modern results" in order to reconstruct the past.[10] He highlights remnants of the past that "do not make sense in present terms". These oddities provide proof that "the world was not made in its present form". As Gould notes elsewhere, God would produce successful "coordination between an organism and its *current* circumstances" (Gould 2002, p. 104, my emphasis).[11] Thus, the divine would create organisms adapted to their present habitat.

Taking these three elements together, Gould conceives of God as a "divine architect" who creates flora and fauna with features perfectly suited to their present-day environments. This Being would not fashion "useless", "odd", or "peculiar" structures that inhibit an organism from fulfilling its extant biological functions. Instead, God would craft features "for current utilities" (Gould 2002, p. 104). The deity would do all things well for the present era.

Of course, from an evolutionary perspective, organs and structures are subject to the vicissitudes of historical contingency. Evolution cobbles them together from whatever parts are available, sometimes jury-rigging these parts in odd ways in an attempt to meet their current biological needs. Thus, evolution often produces imperfect designs for current environments.

Having explained why imperfection is, in general, supportive of evolutionary theory, Gould next turns to his beloved panda. The creature's thumb, he notes, is not really a true thumb at all. That is, the thumb is not a fifth-digit appendage (as on the human hand). Instead, the fifth digit on pandas is a standard-issue claw, suitable for scratching and digging rather than gripping. The 'thumb' is actually an elongated wrist bone called the radial sesamoid. The muscles surrounding this bone allow it to press against the panda's pad—making it opposable—and so enable the panda to manipulate bamboo. But while the thumb is "serviceable. . . for stripping leaves off bamboo shoots" it is nonetheless "highly inefficient" (Gould 1986, p. 63). For Gould (1980, p. 23), this "odd arrangement" provides strong evidence of an evolutionary origin:

> The panda's thumb provides an elegant zoological counterpart to Darwin's orchids. An engineer's best solution is debarred by history. The panda's thumb is committed to another role, too specialized for a different function to become an opposable, manipulating digit. So the panda must use parts on hand and settle for an enlarged wrist bone and a somewhat clumsy, but quite workable,

> solution. The sesamoid thumb wins no prize in an engineer's derby. It is, to use Michael Ghiselin's phrase, a contraption, not a lovely contrivance. But it does its job and excites our imagination all the more because it builds on such improbable foundations. (Gould 1980, p. 24)

And five pages later:

> The panda's 'thumb' demonstrates evolution *because* it is clumsy and built from an odd part, the radial sesamoid bone of the wrist. The true thumb had been so shaped in its ancestral role as the running and clawing digit of a carnivore that it could not be modified into an opposable grasper for bamboo in a vegetarian descendant. (Gould 1980, p. 29, original emphasis)

Two decades later, in his *magnum opus*, *The Structure of Evolutionary Theory* (2002, p. 104), Gould gives a fine summary of his panda argument:

> We observe a single object, but not enough relevant items to forge consilience about its status as the product of history. How can we work from unique objects? How shall we infer history from a giraffe? Darwin tells us to search for a particular form of discordance—some imperfection or failure of coordination between an organism and its current circumstances. If such a quirk, oddity, or imperfection—making no sense as an optimal and immutable design in a current context—wins explanation as a holdover or vestige from a past state in different circumstances, then historical change may be inferred. Call this, if you will, the orchid principle (though I have also designated it as the panda principle for my own favorite example, perforce unknown to Darwin, of the panda's false thumb, Gould 1980), to honor Darwin's argument (1862) for orchids as products of history. Their intricate adaptations to attract insects for fertilization cannot be read as wonders of optimal design, specially created for current utilities, for they represent contraptions, jury-rigged from the available parts of ordinary flowers. [12]

The reference to "Gould, 1980d" is *The Panda's Thumb* (Gould 1980). In the passage above, Gould reiterates his classic argument. Any "imperfection or failure of coordination between an organism and its current circumstances" suggests an evolutionary explanation rather than "optimal and immutable design".

As one might expect, Gould's argument about the panda's thumb draws upon detailed research. In particular, he examines a study by D. Dwight Davis (1964), who was at the time the curator of vertebrate anatomy at Chicago's Field Museum of Natural History. According to Gould, Davis's study "is probably the greatest work of modern evolutionary comparative anatomy" (Gould 1980, p. 22, 43–44). This study shows not just that the panda's 'thumb' is an elongated radial sesamoid but that its hypertrophy could have come about by "a simple genetic change, perhaps a single mutation affecting the timing and rate of growth" (Gould 1980, p. 23).[13] A longer bone would have, in turn, altered the muscles attached to the radial sesamoid so that the capacity for opposability would be a direct mechanical effect of the bone's growth. Thus, a minor genetic change may have ultimately produced the panda's 'thumb.' Such a change is more plausible given that ordinary bears, the giant panda's closest relative, already have a noted ability to manipulate objects with their forelegs and, relative to other carnivores, also have a slightly larger radial sesamoid and a favorable muscular arrangement in the wrist. Moreover, beyond the 'thumb' itself, Gould agrees with Davis that other associated, complex changes can be explained by natural processes. Such changes include, for example, alterations to the form and function of the skull, which are necessary for the transition from an omnivore diet to the panda's almost exclusive bamboo diet. Thus Gould, like Davis, concludes that "very few genetic mechanisms—perhaps no more than half a dozen—were involved in the primary adaptive shift from *Ursus* [bear] to *Ailuropoda* [panda]. The action of most of these mechanisms can be identified with reasonable certainty" (Gould 1980, pp. 43–44).[14]

Taking all of these passages into account, we may now attempt to reconstruct Gould's argument. Recall that he framed the argument as a contrast between evolutionary processes, on the one hand, and "an omnipotent creator", "sensible God", or "ideal engineer" on the other. Whereas God would make perfect adaptive designs for an organism's current environment, evolution would not necessarily do so. As it happens, the panda's thumb is *not* an ideal design for eating bamboo. And natural processes, like genetic mutations and natural selection, can in principle explain changes to the radial sesamoid.

4. The Deductive Formulation

In my view, there are two possible ways to construct Gould's argument. The first is deductive. The second is a likelihood argument. We will analyze each in turn.[15]

On the deductive front, one might articulate the argument as two complementary syllogisms, the first leading to the second:

Deductive argument 1:

1. If an omnipotent creator made the panda's thumb, he would have optimally designed it for its primary function in the panda's current environment; he would *not* have suboptimally designed it or allowed it to become suboptimal for its primary function in the panda's current environment.
2. The panda's thumb is not optimally designed for its primary function in its current environment.
3. Thus, it is not the case that an omnipotent creator made the panda's thumb [1, 2 modus tollens].

Deductive argument 2:

4. Either an omnipotent creator made the panda's thumb or it evolved from a common ancestor with a similar structure.
5. It is not the case that an omnipotent creator made the panda's thumb [3 above].
6. Thus, the panda's thumb evolved from a common ancestor with a similar structure [4, 5 disjunctive syllogism].

A Brief Commentary on the Deductive Formulation

It may help to clarify this reconstruction (cf. Nelson 1996, p. 499). Both arguments are deductively valid. As such, if the premises are true, then the final conclusion is guaranteed to be true. This would constitute "proof" of evolution, as Gould says.

In the first argument, I have articulated premise one using "an omnipotent creator" rather than a "sensible God" or "ideal creator". These terms are not equivalent per se, which suggests that an 'expansive' interpretation of Gould's text may actually support several versions of the panda argument, each involving a specific entity. I have chosen "omnipotent creator" because I think it best captures what Gould had in mind. Readers who disagree can modify the argument accordingly.

More importantly, recall Gould's block quotes (above), in which he emphasizes that God creates structures that match an organism to its current environment. Accordingly, premise one claims that if the Almighty made the panda's thumb, it would be optimally designed for its primary function in the panda's present habitat. I have included the phrase 'primary function' because Gould invariably focuses on the thumb's key function of stripping bamboo leaves rather than any secondary functions. Similarly, Gould's other examples in the same passages also highlight a given structure's key function—for example, a bird's wing for flight—rather than any secondary functions, like keeping a bird warm while nesting.

In addition, premise one includes the idea that God would not *allow* the thumb to become suboptimal vis-à-vis the panda's present-day habitat. Gould holds that if God fashioned the panda's thumb in the past, He would make sure the thumb functions

optimally in the "present" (Gould 1980, p. 28; 2002, p. 104). Thus, the deity's creative forethought ensures the thumb's tight adaptive fit with its contemporary environment.

Premise two portrays Gould's judgment that the panda's thumb is "clumsy" and "highly inefficient" for its key function (Gould 1980, p. 24; 1986, p. 63).

Premise four articulates Gould's characterization of the argument as adjudicating between two main rivals, special creation and evolution: 'Either an omnipotent creator made the panda's thumb or it evolved from a common ancestor with a similar structure.' Unless otherwise qualified, most formulations of a disjunction ('either X or Y') use an inclusive "or", which can be interpreted as "and/or". In this case, however, it is best to read it as an exclusive "or", which means that only one hypothesis can be true, not both. As is transparent in his various writings, Gould held the conviction that 'evolution' and 'special creation' are mutually exclusive explanations rather than complementary accounts. For him, the choice was binary (Gould 1983, pp. 33–40, 42–45; 1977, pp. 11–17; 1991, pp. 309–24).

Evaluation

As one might imagine, most of the action centers on premise one. We will return to this shortly. For now, however, the salient point is that the main drawback of this particular reconstruction is that it does not fully capture Gould's positive case for evolution based on the suboptimality of the panda's thumb. That is, Gould seemed to hold the following: if evolution fashioned the panda's thumb, then it would not necessarily be optimally 'designed' for its primary function in the panda's current environment; we would be unsurprised if it were suboptimally 'designed' for its primary function in the panda's current environment.

This is a straightforward articulation of Gould's claim about the expected outcomes of evolutionary processes. Importantly, this claim does *not* say that evolution *entails* a suboptimal thumb rather than an optimal one. On Gould's view, evolution sometimes produces exquisite designs: "But what nature can do, she often does surpassingly well", he says (Gould 1980, p. 307). So, it is *possible* that evolution could produce an optimal (or nearly optimal) thumb. For Gould, however, evolution is also a tinkerer, and, thus, we would be unsurprised to discover the thumb was suboptimal even if we could not deduce this fact *a priori* from evolutionary theory itself. Even so, Gould gives some degree of positive evidence (or expectation) about the thumb given evolution. One weakness of the deductive reconstruction is that it does not quite capture this positive element.

In a similar way, the deductive reconstruction does not capture Gould's use of the empirical study by Davis. Recall that Davis thought the thumb could have come about by "a simple genetic change, perhaps a single mutation affecting the timing and rate of growth" (Gould 1980, p. 23).[16] As such, Gould believed that a major study had confirmed that the panda's thumb could have been made by evolution. This claim also functions as positive support for evolution. Empirical data confirms the expectations (or predictions) of the theory. Unfortunately, the deductive formulation of the argument does not capture this element clearly.

So, the deductive formulation may not be the best reconstruction. Perhaps, then, one ought to understand Gould's argument in terms of likelihoods?

5. Likelihood Formulation

Another possibility is to frame the panda polemic as a likelihood argument. Philosopher of science Elliott Sober sees it this way: "[Gould] claims that the hypothesis of intelligent design makes the panda's thumb very improbable, whereas the hypothesis of evolution by natural selection makes the result much more probable" (Sober 2008, p. 127). Although Sober misses Gould's particular focus on special creation—rather than on the more general notion of "intelligent design"—nonetheless, we can adapt his formulation accordingly.

As such, let 'E' be evolutionary theory, 'T' be the panda's thumb, and 'C' be special creation by an omnipotent creator. The argument is $Pr(T \mid E) > Pr(T \mid C)$. That is, given

evolutionary theory, the imperfect thumb is more probable than given special creation. Thus, the thumb supports evolution over special creation.

It may be helpful to spell out the argument point by point:

i. The probability is extremely low that "an omnipotent creator" made the panda's thumb suboptimal (or allowed it to become suboptimal) for its primary function in the panda's current environment.
ii. The probability is much higher that evolution fashioned the panda's thumb to be suboptimal for its primary function in the panda's current environment.
iii. The panda's thumb is suboptimal for its primary function in its current environment.
iv. If a datum is more probable on one hypothesis than on another hypothesis (and these hypotheses are mutually exclusive), then the datum supports the former hypothesis over the latter.
v. Thus, the suboptimality of the panda's thumb supports evolution over the claim that an omnipotent creator fashioned it.

A Brief Commentary on the Likelihood Formulation

Point (iv) above does much of the heavy lifting. It is an expression of the "law of likelihood", which articulates a way that a fact (or piece of evidence) can favor one hypothesis over a competitor. More precisely, it holds that datum D favors hypothesis H_1 over hypothesis H_2 if and only if D is more probable on H_1 than on H_2.[17] Suppose I have two friends, Ken and Henry, who independently enjoy stealing my vintage rum from time to time. Ken takes my rum fairly often, whereas Henry takes it very rarely. If my rum goes missing, I can safely conclude that this fact favors the 'Klepto-Ken' hypothesis over the 'Henry-heist' hypothesis.

This basic reasoning applies to point (iv) above. According to Gould, a suboptimal thumb is more probable given the 'evolution' hypothesis than given the 'omnipotent creator' hypothesis. These expectations are articulated in points (ii) and (i) above, respectively. Thus, given the fact that the panda's thumb is suboptimal (as in point iii above), it follows that this fact favors the evolutionary hypothesis more than the God hypothesis.

Evaluation

One of the nice features of the likelihood formulation is that it captures what was missing in the deductive formulation: Gould's belief in positive evidence for an evolutionary hypothesis. Recall that Gould drew on Davis's careful empirical study, which apparently showed that the thumb could have come about by a "simple genetic change". This result arguably raises the probability that the thumb arose through evolutionary mechanisms. (Or, more modestly, this result at least lessens the improbability that the thumb came about by evolutionary means.) This formulation captures this element.

The likelihood approach also allows a degree of flexibility in terms of the amount of support the thumb provides for evolution over special creation. That is, the more Gould (or anyone else) can show that the thumb is much more probable given evolution than given an omnipotent creator, the stronger the thumb favors evolution over its rival. And a similar result is true in the opposite direction: if one thinks the probabilities between the two hypotheses about the thumb are closer together, the likelihood formulation still provides a way to articulate that idea.

Yet this is also where the likelihood of formulation appears to differ from Gould's own understanding of the argument. Gould tacitly accepts an epistemic principle much stronger than the law of likelihood. He repeatedly uses the word "proof" in the context of the panda argument (Gould 1980, pp. 13, 20, 28), claiming that the argument "demonstrates evolution" (Gould 1980, p. 29). More generally, Gould asserts that imperfections are "the primary proofs that evolution has occurred" (Gould 1977, pp. 90–91; 1980, p. 13; 1983, p. 55, see also pp. 131, 160, 258; 1991, p. 61). Imperfections also disprove the creation hypothesis, supplying "proof that the world was not made in its present form" (Gould 1980, pp. 28–29).[18] Of course, *proving* one hypothesis and *disproving* another is quite different

than *favoring* one hypothesis over the other. 'Favoring' is much more modest; it only states that the evidence supports one claim more than another, to whatever extent. It typically comes in degrees. Both hypotheses could end up being false. Or a third hypothesis might be formulated that is favored by the evidence when compared to either of the previous hypotheses.

Proof, on the other hand, is ironclad. It establishes a given hypothesis with certainty. It is not degreed, not even settling for a very high degree of probability. It is also impregnable to being overturned by a (future) formulation of a rival hypothesis that might try to account for the data in a more convincing way. Proof is proof.

So, the likelihood version departs from Gould's own description of the argument. While a likelihood approach has many advantages over Gould's notion of "proof" and deductive certainty, it is important to note the marked difference. Commentators such as Elliott Sober have overlooked this exegetical point.

To this point, we have not yet visited the most controversial claim of the likelihood formulation. When it comes to evaluating the argument, much attention ought to be given to (i) above, the claim that the probability is extremely low that "an omnipotent creator" made the panda's thumb suboptimal (or allowed it to become suboptimal) for its primary function in the panda's current environment. We will turn to this idea in due course.[19]

Stepping back, I have formulated two versions of the panda argument. While much analysis remains ahead, perhaps this initial examination helps illuminate ways that a person might understand an argument that Gould himself prized. In his view, if ever there was a single artifact that could demonstrate descent with modification, the panda's thumb was it.

6. Critical Appraisal of Key Claims

In what follows, I will critically analyze several elements of the two formulations above. In each case, I will argue that, depending on a person's background beliefs, there may be good grounds for a wide range of people to reject both versions of the panda argument.

6.1. Only Two Options?

We begin with premise four of the deductive argument, which holds, "Either an omnipotent creator made the panda's thumb or it evolved from a common ancestor with a similar structure." For Gould, these two options were the *only* viable ones. In the immediate context of his seminal essays on the panda, he does not give any hint that there might be a third (or fourth) possible explanation worth considering. Elsewhere, he analyzes and rejects the thesis that God, rather than unguided nature, is the best explanation for suffering in the natural world and the improbable results of evolution (Gould 1991, pp. 309–24; 1983, p. 33–40, 42–45). In general, however, Gould more or less uncritically adopts the dichotomy allegedly laid out in the *Origin*: either descent with modification or special creation. Unfortunately, this neither captures the nuances of the *Origin* nor the contours of Gould's own era (Gillespie 1979, pp. 19–40; Hunter 2021a, 2021b).

The deeper question, however, concerns who is rationally obligated to accept premise four (cf. Nelson 1996, p. 502). Apparently, very few. William James' classic text, *The Varieties of Religious Experience*, for example, plausibly demonstrates the great diversity of religious beliefs worldwide—much more varied than Gould's simple dichotomy—and also indirectly implies that Gould's two 'viable' theories are hardly essential "characteristics of the religious life" (James [1904] 2002, p. 485). In fact, premise four elides a host of entities, processes, or deities found in pantheism, process theism, henotheism, polytheism, apophatic theism, religious pluralism, Confucianism, religious Taoism, Theravada Buddhism, Mahayana Buddhism, Nirguna Brahman-oriented Hinduism, Platonism, and the like (Dilley and Tafacory 2019, p. 47). While Gould may have good reasons to reject these possibilities, his premise makes a claim that many people worldwide would not

be rationally obligated to accept. Without further grounds from Gould, such people are (presumably) justified in denying premise four and, hence, the panda argument.

This is no fault of the premise, of course. One cannot reasonably expect Gould to exhaustively justify the premise with respect to every major worldview not covered by his two favored options. As such, the present point is *not* to criticize Gould's premise per se but rather to make an observation: the premise appeals to a circumscribed range of people.

6.2. Suboptimality?

Both the deductive and likelihood formulations claim that the panda's thumb is suboptimal. Oddly, Gould does not give strong reasons to accept this claim; nowhere in his writings does he provide a detailed empirical study that demonstrates the suboptimality of the panda's thumb. The major research that Gould relies upon, Dwight Davis's study, used a *dead* panda for its conclusions about comparative morphology; it did not examine how effective living pandas are at stripping bamboo leaves. Biologist John Gittleman notes that the analyses of both Davis and Gould arose "despite any real information on how the giant panda lives in nature" (Gittleman 1985, p. 524). The first major study of living pandas—focusing specifically on their adaptation to bamboo—was conducted by George Schaller's team, which published its results in *The Giant Pandas of Wolong*. They observed that pandas "efficiently bring food to the mouth with their forepaws" and "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" (Schaller et al. 1985, pp. 4, 215). Further:

> When watching a panda eat leaves, stem or new shoots we were always impressed by its dexterity. Forepaws and mouth work together with great precision, with great economy of motion, as the food is grasped, plucked, peeled, stripped, bitten and otherwise prepared for being swallowed. Actions are fluid and rapid. . . . (Schaller et al. 1985, p. 58)

Similarly, in 1999, a team of Japanese scientists used computed topography, magnetic resonance imaging, and live observation to analyze the structure and function of the panda's thumb. They reported that the "radial sesamoid" and its accessories enable the panda to "manipulate objects with great dexterity" (Endo et al. 1999, p. 309). In fact, the "way in which the giant panda, *Ailuropoda melanoleuca*, uses the radial sesamoid bone—its 'pseudo-thumb'—for grasping makes it one of the most extraordinary manipulation systems in mammalian evolution" (Endo et al. 1999, p. 309).[20] They conclude that "the hand of the giant panda has a much more refined grasping mechanism than has been suggested in previous morphological models", including Davis's model (Endo et al. 1999, p. 310).

In fairness to Gould, Schaller's team published its work in 1985, followed by the Japanese team in 1999, while Gould published his initial articles on the panda's thumb in 1978. However, Gould continued to champion the thumb as his premier example of imperfection until his death in 2002, never conceding the conclusions of these careful studies. As a curious aside, Gould positively praises the thumb's function in his original 1978 article. Recounting his trip to the Washington zoo as a boy, he writes, "I was amazed by their dexterity and wondered how the scion of a stock adapted for running could use its hands so adroitly" (1978, p. 24).

Thus, by way of an assessment of the 'suboptimality' claim: not only does Gould fail to offer empirical evidence for the suboptimality of the thumb, but key empirical studies of the thumb suggest quite the opposite.[21] Yet, because this claim is essential to both the deductive and likelihood formulations of the panda argument, a person who rejects the suboptimality claim would likewise reject the panda argument.

6.3. The Ways of the Almighty

Just what would an omnipotent creator do? Recall premise one of the deductive formulation: 'If an omnipotent creator made the panda's thumb, he would have optimally designed it for its primary function in the panda's current environment; he would *not* have

suboptimally designed it or allowed it to become suboptimal for its primary function in the panda's current environment.' Recall also a key claim in the likelihood formulation: 'The probability is extremely low that "an omnipotent creator" made the panda's thumb suboptimal (or allowed it to become suboptimal) for its primary function in the panda's current environment.'

These two claims are not identical, of course. The former specifies what God *would* do (or would not do); the latter gives only a probability. But they both share a common thread about what to expect (or not expect) from the deity. On both views, it is highly unexpected, at the very least, for God to create (or allow) a suboptimal thumb. For ease of reference, I will refer to this common thread as "premise one". (So, to be clear, in what follows, by "premise one", I do not just have in mind the first premise of the deductive formulation but also the first statement (i) of the likelihood argument. Thus, my statements about "premise one" will apply to each formulation *mutatis mutandis*.)

Premise one requires analysis. Just what is the justification for it? And who can rationally reject it? To approach these questions, it is important to recognize that Gould did not simply limit himself to claims about the alleged actions of an "omnipotent creator". He also referred to a "sensible God", "rational agent", and "ideal engineer" (Gould 1980, p. 20; 1983, p. 160). These terms are not all the same, and each one gives the panda argument a unique meaning. Consider: 'If a rational agent made the panda's thumb, he would have optimally designed it for its primary function in the panda's current environment; he would *not* have suboptimally designed it or allowed it to become suboptimal for its primary function in the panda's current environment.' The term 'rational agent' does not denote properties of omnipotence, benevolence, aseity, or the like. On some views, a 'rational agent' is a person who fundamentally maximizes self-interest, a notion with few implications about pandas or thumbs. Based on my reading of Gould, an "omnipotent creator" seems most in keeping with his intent; nonetheless, both the meaning and justification of the panda argument radically depend upon which agent one considers.

Having clarified the content of premise one, we may now ask: Who is rationally obligated to accept it? That is, who is rationally obligated to accept that God would not make (or allow) the panda's suboptimal thumb or that the probability is 'extremely low' that God would do so? These questions are more difficult to answer than one might think—in no small part because they breed a further array of queries. Given that Gould believes God would (probably) not allow a suboptimal thumb in the *present*, one might ask: on Gould's view, what should God do if the environment changes? Should God prevent change? If so, to what degree should He maintain stasis? Or should God create new animals, as the famous nineteenth century scientist Georges Cuvier believed? Perhaps He should instead act parsimoniously and limit Himself just to modifying extant animals?[22]

These are non-trivial questions, and Gould elides them. But more to the point, he gives no justification for the assumption he *does* make—namely, that it is highly unexpected (at the least) for God to create a suboptimal panda's thumb. Gould apparently assumes that an omnipotent Being would only behave in the manner purportedly specified by one particular version of creationism ('special creation'). Yet Gould provides no positive grounds for this assumption.

A lack of positive grounds would not be a problem if special creationist theology were obviously true. But it hardly seems to be. Alternatively, a lack of positive grounds would be fine if Gould simply borrowed his contemporary adversaries' background beliefs and, on that basis, showed how the natural world better accords with evolution than with their theories. In other words, the theology in the panda argument does not require independent justification if all parties in the conversation *already* accept this theology. But such is not the case. As we will see, the panda argument relies on *positiva* theology—propositions about God not necessarily held by contemporary design-based rivals.[23] As stated, Gould's argument is only attractive to thinkers who *already* believe that, if God made the panda's thumb, He would do so as premise one describes. Gould provides no positive grounds to sway any dissidents toward his partisan view.

None of this is to say that design-based rivals are correct. Nor is it to defend their views of God, intelligent agency, or related matters. But it is to point out that, unless rivals are given reasons to abandon their current views, they are not rationally obligated to accept Gould's God-talk and, hence, are not rationally obligated to accept the panda argument.

The point applies widely for the simple reason that, in light of *their* background beliefs, a number of thinkers do not appear to be rationally obligated to accept Gould's theology. Of course, some of them may be within their epistemic rights to accept this premise, but this does not mean they *must*. Instead, the relevant question is: who can sensibly reject Gould's theology? Consider, for example, a mainstream orthodox Christian view of premise one. This view may include difficulties for a generalized form of this premise. A generalized form holds that if God had created an organism or structure in the past, He would (almost surely) optimally design it for the organism's environment in the present. Many Christians do not accept this claim in part because they believe in the doctrine of the Fall, which holds that, due to creaturely rebellion against God, the natural world is no longer in its pristine state. This doctrine is arguably one of the most influential ideas in world history, affecting a wide range of human ideas and activities, including the rise of modern science itself (e.g., Harrison 2007). Genesis intimates the effect on the natural world:

> And to the man, [God] said,
>
> . . . cursed is the ground because of you;
>
> in toil you shall eat of it all the days of your life;
>
> thorns and thistles it shall bring forth for you. . .
>
> By the sweat of your face you shall eat bread
>
> until you return to the ground. . .
>
> you are dust, and to dust you shall return. (Genesis 3: 17–19)

Paradise lost; toil and death gained. In the Christian tradition, the majority of modern commentators as well as many Church Fathers believe Saint Paul spoke directly about the effects of the Fall on creation in his famous letter to the Roman church:

> For the creation waits with eager longing for the revealing of the children of God; for the creation was subjected to futility, not of its own will but by the will of the one who subjected it, in hope that the creation itself will be set free from its bondage to decay and will obtain the freedom of the glory of the children of God. We know that the whole creation has been groaning in labor pains until now. . . . (Romans 8: 19–22)[24]

And in his commentary on the Book of Isaiah, John Calvin contrasts the prophet's irenic vision of the natural world before the Fall with animal cruelty and violence after:

> [Isaiah] describes the order which was at the beginning, before man's apostasy produced the unhappy and melancholy change under which we groan. Whence comes the cruelty of brutes, which prompts the stronger to seize and rend and devour with dreadful violence the weaker animals? There would certainly have been no discord among the creatures of God, if they had remained in their first and original condition. When they exercise cruelty towards each other, and the weak need to be protected against the strong, it is an evidence of the disorder. . . which has sprung from the sinfulness of man. (Calvin [1550] 1892, p. 383)

While not all Christians accept this view, millions do. Whether or not this doctrine is correct, supported by the Bible, or endorsed by the Church Fathers is much beside the point. What matters is that, given *this* background belief in the Fall, these Christians are not rationally obligated to accept Gould's theology and, hence, his panda argument.

In light of this version of Christianity, one might be unsurprised to find that contemporary creationists and intelligent design theorists—Gould's specific adversaries—also typically reject premise one. This is not to say that their reasons for doing so are strong, but only to point out that Gould has given them no grounds to replace their own views of the divine (or of intelligent agency) with those of the panda argument.

In the present day, young earth creationists routinely claim that the Fall of man adversely affected the created order such that it is no longer optimal. In the seminal text of modern creationism, *The Genesis Flood*, Henry Morris and John Whitcomb argue that the original creation was without flaw, but "the Edenic curse had far-reaching effects upon nature" including physical changes to animals as well as predation and death (Whitcomb and Morris 1961, p. 459). Andrew Snelling argues a similar line in *Earth's Catastrophic Past* (2010), arguably the most comprehensive defense of creationism today.[25] He contends that creation was originally "complete and perfect. There was nothing out of order—no pain, no suffering, no disease, no struggle for existence, no disharmony, no sin or evil, and above all, no death" (Snelling 2010, vol. 1, p. 245). But "[m]an's fall from his created state of innocence" had a "pivotal effect upon. . . the whole earth" which adversely altered the animal kingdom, humankind, and even "the very elements of the ground itself" (Snelling 2010, pp. 253, 245–59). Snelling, Morris, and Whitcomb are hardly alone. To my knowledge, nearly all contemporary young-earth creationists affirm the existence of an omnipotent God *and* the adverse effects of the Fall on creation (Nelson 1996, p. 500). Given the degraded state of creatures and their environment, it is hardly surprising that some organisms are poorly adapted to their current ecological niche.

Likewise, intelligent design theory itself does not entail the acceptance of premise one. The theory holds that certain features of the natural world are best explained by detectable intelligent agency rather than mindless materialistic processes like natural selection and random mutation (Meyer 2013, p. 339). While ID theorists generally expect to find well-engineered systems or organisms in the natural world (Miller 2022), the theory is consistent with at least some degree of 'devolution' in the present day (e.g., Minnich and Meyer 2004, pp. 301–2). And the theory itself focuses on intelligent agency rather than the theology-rich concept of an "omnipotent creator". Thus, insofar as a person accepts ID theory, she has grounds (in principle) to refrain from accepting premise one.

Moreover, intelligent design theorists can accept additional claims that more directly run contrary to premise one. For example, William Dembski holds that "[i]f humans are indeed the crown of Creation", then "on theological grounds" it seems "entirely reasonable for human sin to have repercussions throughout the physical world" (Dembski 2009, p. 39). These repercussions include not just suboptimal designs but outright natural evil. In fact, Dembski accepts that God himself brought "about natural evil" in part to help human beings understand the seriousness of sin as well as their need for redemption (Dembski 2009, pp. 37, 150).[26] On this view, one can reject the notion that God created *only* optimal designs in the biological realm. Similarly, one can accept that God knew about the Fall (logically) prior to the moment of creation and thus *deliberately* created suboptimal organisms for punitive and redemptive purposes.[27]

More deeply, advocates of contemporary creationism, intelligent design, or related views can take matters one step further. Even aside from their own theories, there are independent (religious) reasons to think that suboptimal designs that have no purpose at all—not even salvific purposes—are fully compatible with the creative activity of an omnipotent creator. Philosopher Peter van Inwagen has argued that gratuitous evil poses no threat to God's existence (van Inwagen 1995, 2006). Evil is 'gratuitous' when it is unnecessary either for some compensating good *or* to prevent some worse (or equally bad) evil. If van Inwagen is correct, then an appendage that functions inefficiently and is not balanced by *any* compensating goods may be compatible with the claim that God created it. On this view, 'gratuitous suboptimality', as we may call it, is no objection to a creative deity.

Taking a step back, various thinkers have offered several ways to reject Gould's theology. In their view, God could have (i) created everything good but, for corrective and redemptive purposes, allowed the Fall to mar the biological realm, (ii) directly created suboptimal designs for divine purposes, or (iii) allowed suboptimal designs *sans* offsetting goods. By enumerating these three options, I do *not* mean to endorse any of them or to claim that any of them are plausible. Instead, the main point is that, in light of *these* views (taken on their own terms) and in light of Gould's lack of apologetic for special

creationist theology, a range of contemporary thinkers are not rationally obligated to accept premise one.

Even if we were to charitably confine Gould's argument to Darwin's era, problems still remain. Perhaps the most prominent creationists of that day—Louis Agassiz and William Paley—would *also* not be obligated to accept Gould's theology.[28] Take Louis Agassiz, for example. In his greatest theoretical work, *Essay on Classification* (1859), he defends what we might call 'taxonomic creationism.' Agassiz believes that species are incarnations of ideas in the mind of God, and their (taxonomic) relations reflect a grand divine plan. On this view, God created basic organismal types that allow variation, some of which are less functional than others. He did not create each species (or structure) optimally adapted to its (current) environment, a point Agassiz drives home early in the work:

> The argument for the existence of an intelligent Creator is generally drawn from the adaptation of means to ends, upon which the Bridgewater treatises, for example, have been based. But this does not appear to me to cover the whole ground, for we can conceive that the natural action of objects upon each other should result in a final fitness of the universe and thus produce an harmonious whole; nor does the argument derived from the connection of organs and functions seem to me more satisfactory, for, beyond certain limits, it is not even true. We find organs without functions, as, for instance, the teeth of the whale, which never cut through the gum, the breast in all males of the class of *mammalia*; these and similar organs are preserved in obedience to a certain uniformity of fundamental structure, true to the original formula of that division of animal life, even when not essential to its mode of existence. The organ remains, not for the performance of a function, but with reference to a plan, and might almost remind us of what we often see in human structures, when, for instance, in architecture, the same external combinations are retained for the sake of symmetry and harmony of proportion, even when they have no practical object. (Agassiz 1859, pp. 11–12)

Agassiz clearly rejects the notion that "an intelligent Creator" would (probably) create or allow only optimal biological designs.[29] On this view, God does not produce every structure for a function but rather creates according to a (taxonomic) plan in which aesthetic elements like "symmetry and harmony of proportion" sometimes take precedence over biological utility. Indeed, one might *expect* cases of inutility. The deity is an artistic architect rather than a spartan engineer.

Strikingly, William Paley also implicitly rejects Gould's theology. In *Natural Theology* (1809), he argues for the existence of an omnipotent deity based on organismal adaptation. Yet he thinks that limited cases of imperfection pose no difficulty because the sheer quality and quantity of exquisite adaptations provide a preponderance of evidence for the existence and traditional attributes of God (Paley 1809, pp. 56–58). As such, Paley points out that an ostrich's wings can be "reckoned an imperfection in the bird" because, "although they may greatly assist it in running, do not serve for flight" (Paley 1809, p. 220). Paley also allows "totally useless" structures as long as they are "extremely rare" (Paley 1809, p. 59). (Notably, Gould does not believe the panda's thumb is totally useless but rather "workable" (Gould 1980, p. 24)). So, Paley's creationism is consistent with the existence of a clumsy panda's thumb.

Stepping back, we see congruity between Paley and Agassiz, two of the most prominent figures in the 19th century debate about biological origins. Despite their starkly different approaches to natural theology, both hold that God's concern in creation is not exclusively aimed at optimal design at the species level, much less with respect to current habitats. For Agassiz in particular, the deity took other elements into consideration, such as beauty, symmetry, and cosmic-level harmony. Oddly, Gould himself was familiar with Agassiz's and Paley's views yet apparently did not realize that they raised difficulties for his panda argument (see Gould 2002, pp. 260–81).

To summarize, premise one claimed that an omnipotent creator (almost surely) would not have suboptimally designed the panda's thumb for its primary function in the panda's

current environment. Such a Being neither creates nor permits poor function. But not only does Gould fail to offer positive support for his view, quite a few thinkers in the discussion have ample reasons to reject it. Such thinkers include taxonomic creationists, Paleyian creationists, contemporary young-earth creationists, intelligent design theorists, mainstream Christians, and many others.

7. The Likelihood Formulation One More Time

As we have seen, a wide array of people are not rationally obligated to accept Gould's theology. That is, many people are justified in rejecting either (or both) premise one of the deductive formulation or statement one of the likelihood formulation. Naturally enough, this has significant implications for whether such people should accept the panda argument as a whole.

Having said that, it is also important to note that there is more going on in the likelihood formulation than just Gould's theology-laden claim. The point of the likelihood argument is to *contrast* special creation with evolution. That is, while an imperfect thumb is compatible with the activity of an omnipotent creator, nonetheless, it is said to be *less* expected on this view than on evolution. The deity tolerates a few screw-ups; evolution tolerates a lot. Thus, even if many people are not rationally obligated to accept the one-off claim that 'God would probably not create or allow the suboptimal thumb', the deeper point is to contrast evolution with special creation. The likelihood version holds that evolution fits the data *better* than creationism does. The point is to compare the two in light of the evidence; when that happens, evolution emerges as the victor.

The likelihood formulation is formidable, and evaluating it comprehensively involves a number of interesting issues. For now, however, I simply want to observe that the matter may be more difficult than it first appears. Just how much does the panda's thumb favor evolution over its rival? Once again, the extent depends in part on what an omniscient creator would do. Religious traditions set the boundaries in different places. Even *within* each of the monotheistic religions, different sects have varied ideas about the matter. Unsurprisingly, these sects also often disagree about the quality and quantity of (expected) disarray in the created order. Some believers regard this disarray as deep and pervasive. For example, Alvin Plantinga suggests that God may have allowed the incarnation, death, and resurrection of His Son as an unrivaled great-making property of the universe and as a remedy to the problem of creaturely rebellion. But "if the remedy is to be proportionate to the sickness . . . [our] world will contain a great deal of sin and a great deal of suffering and pain. Still further, it may very well contain sin and suffering, not just on the part of human beings but perhaps also on the part of other creatures as well" (Plantinga 2011, p. 59). Such sin and suffering may explain creaturely "predation, waste and pain" (Plantinga 2011, p. 59). On this view, we might be unsurprised to find *many* suboptimal designs—perhaps even as many as we would expect given evolution. If so, then such imperfections do not favor evolution over creation.

Whether Plantinga is correct or not is quite beside the point. Whether one is an atheist, agnostic, theist, or other, the deeper issue is that one's conception of God (and perhaps related matters, like creaturely freedom) radically shapes the extent to which the panda's thumb supports evolution over a given God-based view.[30] The likelihood formulation of the panda argument will have to engage serious theological issues in order to claim success. Perhaps this can be done, but the task is hardly trivial.

Why is this worth pointing out? First, expositions of the panda's thumb argument rarely, if ever, acknowledge these matters, much less address them. Second, as noted, some prominent biologists make theology-laden arguments for evolution, yet likewise fail to do so with theological substance. Indeed, theology-laden defenses of current evolutionary theory in technical literature, popular writing, and textbooks nearly always lack theological and metaphysical rigor.[31] In these contexts, the assertion that imperfection bolsters evolution over design-based rivals leaves much territory unexplored.

A second and deeper challenge concerns the claim that the panda's thumb is, in fact, suboptimal. The suboptimality of the thumb is essential to the argument, functioning as its crucial evidence. In the likelihood formulation, the argument claims that an imperfect thumb is more expected given evolution than given special creation. But to make this claim, one must determine what counts as an *imperfection*. And this is no small task given the theological context of the argument, especially with an "omnipotent creator" in view. As philosopher of biology Paul Nelson observes:

> 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 than 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. . . can only be judged only on the scale of the whole creation. (Nelson 1996, p. 503, original emphasis)

The panda argument depends on the judgment that the panda's thumb is imperfect. If this judgment is to be sound, then the proper metric of evaluation must be utilized. But *what* is the proper metric—local biological adaptation, cosmic harmony, salvation history, eschatological redemption, or something else? Even if the thumb performs its biological function poorly, it may have a more important function in the divine economy. To claim that the thumb's primary function is *biological* implies that God is mainly concerned with, or only able to affect, a relatively narrow range of possibilities. But what is the evidence for this assumption? Human artists and inventors sometimes craft work for moral or aesthetic purposes rather than mere functional ones, for example.

Arguably, human cognition faces strenuous demands when assessing the proper metric for God's purposes with the panda's thumb, especially when cosmic harmony, salvation history, eschatological redemption, and divine aesthetics are live possibilities. Just how does Gould *know* what the deity had in mind for the radial sesamoid? Philosopher Elliott Sober summarizes the point:

> Creationists don't need to assert that *they* know what God would have had in mind if he had built the panda. All they need to say is that *Gould* does not know this. Gould adopts assumptions about the designer's goals and abilities that help him reach the conclusion he wants—that intelligent design is implausible and Darwinian evolution plausible as an explanation of the panda's thumb. But it is no good simply *inventing assumptions* that help one defend one's pet theory. Rather, what is needed is *independent evidence* concerning what God (or some other intelligent designer) would have wanted to achieve if he had built the panda. And this is something Gould does not have. (Sober 2008, p. 128, original emphasis).[32]

Thus, in order for the likelihood formulation to carry the day, serious theological work remains to be done. In particular, affirmation of the thumb's suboptimality requires analysis of divine purposes or goals at the relevant scale, whether local, cosmic, redemptive, aesthetic, or otherwise. But without a sound judgment of the thumb's imperfection, the argument loses its central evidence. This is not to say that such a judgment cannot be reasonably made, but only to make the modest point that any such judgment requires substantive theological reflection.[33]

A final problem with the likelihood argument includes a self-referential concern. (As it happens, this concern applies to the deductive version as well.) Those inclined toward the argument often agree with Gould that evolution is an unplanned and unguided process that leaves humans poorly equipped to discern the alleged purposes of a putative deity. As I will briefly explore in Section 10 below, those who accept this view may be unjustified in accepting the panda argument or indeed many *positiva* arguments for evolution.

8. An Objection and Reply

But scholars familiar with Gould's work might raise an objection. Some may worry about my characterization of the panda argument as a polemic for common ancestry and against special creation. A critic might suggest that Gould's aim was instead to establish exaptation and attack adaptationism.[34] Gould's interest in the panda's thumb might be viewed as a modest precursor to his more technical and developed arguments for these ends. On this view, the panda's thumb is a weird, unique, and exapted structure in the broader context of comparative morphology. The thumb is odd, peculiar, and incongruous by comparison to the thumbs of other organisms—such as those of apes, which have 'typical' thumbs rather than extensions of their radial sesamoids. It is "clumsy" in terms of where it has come from, not necessarily its present-day use. Thus, it would be wrong to think that Gould characterized the thumb as "sub-optimal" in the sense of having poor function. By contrast, he thought of it as an exaptation. Exaptations can function reasonably well but still be identifiable as odd, peculiar, clumsy, and incongruous in comparison to the features of other animals. So, it is a mistake to characterize Gould's argument as focusing on suboptimality and, by extension, as an argument for common ancestry and against special creation. Instead, it is better described as an argument for evolution as a messy, haphazard, improvising process—a process of contingency rather than one primarily marked by, say, the finely sculpting hand of natural selection.

I raise four points by way of reply. First, I quite agree that Gould's writings about the panda's thumb are part of his apologetic for exaptation and his critique of adaptationism. The textual evidence is clear that Gould had these ends in mind. In fact, I am even happy to concede, if need be, that these are his *primary* purposes. But it would be an overstatement to claim that these are his *only* purposes. Great thinkers can have more than one purpose for a given argument (or set of arguments). As I will show below, Gould had in mind more than just exaptation and anti-adaptationism.

Second, my primary concern is not with Gould's supposed purposes but, once again, with the *argument* as he straightforwardly presented it. Arguments and their premises stand or fall on their own. Moreover, as a de facto reality, the panda argument has been and remains widely deployed by other thinkers as a polemic for evolution and critique of creationism or intelligent design (e.g., Salesa et al. 2006, p. 381; Prothero 2007, pp. 37–38; Dawkins 1986, p. 91; Rice 2007, p. 2; Futuyma 2013, pp. 613–14, 639). Whether Gould intends it or not, the panda argument has played this role and continues to do so. It can be studied as such.

Third, but even setting this point aside, the objection above misses the common conceptual thread that, for Gould, tied adaptationism and special creation together. Both views emphasize optimal or near-optimal design. In one case, God is the craftsman; in the other, natural selection. In either case, species are well-adapted to their particular environment. (More so in the case of divine design.) But both views stand or fall on the level of optimality present in the natural world. For Gould, clear examples of suboptimal adaptation count as evidence against these views. In the case of adaptationism, Gould believes that suboptimality indicates that natural selection plays a lesser role in survival and reproduction than adaptationists believe. In the case of special creation, Gould thinks that suboptimality indicates that a divine explanation is less plausible than a tinkering, evolutionary one. For Gould, *both* views share similar internal logic, and so he marshals suboptimality as evidence against the duo. Thus, to claim that 'Gould has only one purpose in mind in his suboptimality arguments' misses his understanding of the conceptual connection between adaptationism and special creation.

Fourth, in any case, the textual evidence is unmistakable. Gould regards the panda argument as establishing common ancestry and upending creationism. He is also clear that sub-optimality is part of the picture. At the risk of being repetitive or pedantic, I have reiterated some of Gould's language in what follows. For example, Gould frames the panda argument as modeled on Darwin's argument about orchids. But it is clear that Gould regards Darwin's argument as a polemic against special creation and for evolution.

Paraphrasing Darwin, Gould writes: "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" (Gould 1980, p. 20). After stating that orchids "were not made by an ideal engineer" but are "jury-rigged", Gould concludes, "Thus, [orchids] must have evolved from ordinary flowers" (Gould 1980, p. 20). The basic framing is clear: special creation by God versus evolution from a common ancestor.

It is also clear that sub-optimality is in view. Gould goes on to explain that:

> [P]erfection of organic design had long been the favorite argument of creationists, who saw in consummate engineering the direct hand of a divine architect... But, Darwin reasoned, if organisms have a history, then ancestral stages should leave remnants behind. Remnants of the past that don't make sense in present terms—the *useless*, the odd, the peculiar, the incongruous—are the signs of history. (Gould 1980, p. 28, emphasis altered)

'Uselessness' is a clear type of sub-optimality, a species of poor function. Moreover, the contrast with "consummate engineering" likewise implies less than perfect function. Well-engineered objects are typically marked by good function. Of course, they may have other fine features as well, such as aesthetic elegance. But they typically have these in addition to good function. It would be very odd to characterize an object as having "perfect" design and yet have *no* implications about its performance.

More to the point, Gould is clear that all of this framing and language about orchids applies directly to the panda argument. He makes this transparent in his *magnum opus*, his mature characterization of the panda argument:

> If such a quirk, oddity, or imperfection—making no sense as an optimal and immutable design in a current context—wins explanation as a holdover or vestige from a past state in different circumstances, then historical change may be inferred. Call this, if you will, the orchid principle (though I have also designated it as the panda principle for my own favorite example, perforce unknown to Darwin, of the panda's false thumb, Gould 1980), to honor Darwin's argument (1862) for orchids as products of history. Their intricate adaptations to attract insects for fertilization cannot be read as wonders of optimal design, specially created for current utilities, for they represent contraptions, jury-rigged from the available parts of ordinary flowers. (Gould 2002, p. 104).[35]

Notice the language of imperfect function. Gould states that "imperfection" makes "no sense as an optimal or immutable design in a current context". Orchids, like the panda's thumb, are not "specially created for current utilities". These are clear statements about suboptimality in the sense of poor *current* function. (This dovetails with Gould's language elsewhere that the thumb is "highly inefficient" (Gould 1986, p. 63).) Thus, Gould is not (simply) claiming that the thumb is clumsy or odd in comparison to the thumbs of other organisms. He is (also) making a statement about its functionality.

Moreover, the language of "specially created" features once again highlights the overall importance of creationism as Gould's adversary. In fact, the whole paragraph is framed as a contest between this adversary and evolution: "optimal and immutable design in a current context" cannot explain what appears to be "a holdover or vestige from a past state in different circumstances" and, thus, "historical change may be inferred". Gould's attack on adaptationism is no doubt close at hand. But it is difficult to say that creationism is not also in the picture: why else attack the idea of "specially created" features?

In summary, then, there are good reasons to accept my interpretation of Gould's panda argument. As mentioned, one can accept that Gould's *primary* purpose is to establish exaptation and criticize adaptationism, if need be. But there is also strong evidence that this was not his only purpose and that he also had in mind the argument that I have analyzed above.

9. A Brief Exposition of the Theological Elements of the Panda Argument

Given that God-talk is clearly in play, it may be helpful to recapitulate several theology-related features of the panda argument. The first notable feature of the argument is that it *requires* theology to be persuasive. In either formulation, the argument's non-theological claims on their own cannot substantiate their respective conclusions. So, Gould's argument depends on God-talk. Of course, a different version of the argument that focuses exclusively on the actions of a "rational agent" will not per se engage theology. But any version that invokes a divine being will do so.

Second, Gould's theology serves as part of his *positive* case for evolution. The scientist thinks "oddities" and "imperfections" count as strong grounds to favor evolution over creationism, not just to reject creationism alone (Gould 1980, p. 28). If Gould removes theology entirely from the panda argument or from his imperfection arguments generally, he loses "the primary proofs that evolution has occurred" (Gould 1977, pp. 90–91; 1980, p. 13; 1983, p. 5; see also pp. 131, 160, 258; 1991, p. 61).

Third, as we have seen, Gould's theological claims are partisan. Gould does not borrow the tenets of his various creationist rivals to show *on their own grounds* that the facts of the natural world support evolution more than them.[36] Instead, Gould imports his own *positiva* intuitions about what a "sensible God" would do. In short, Gould's theology is sectarian relative to a range of perspectives, including some, like young-earth creationism, that are heavily involved in origins discussions.

As mentioned, Gould is not alone. Some prominent biologists likewise use *positiva* theology in some of their arguments for evolution. This occurs not just in debates with creationists or intelligent design theorists but even in 'neutral' or 'purely scientific' contexts like encyclopedia entries or textbooks (Nelson 1996, pp. 497, 506–8). That is, even when the rhetorical setting is a straightforward description of the reasons for evolution, theological claims often surface. In fact, a 2019 study of 32 biology (and evolution) textbooks—including the top 12 in the United States—indicated that around 80% of them use theology in a tendentious way in their case for evolution (Dilley and Tafacory 2019). Thus, some of the challenges that plague the panda argument apply elsewhere too.

10. Still More Reasons

Additional considerations raise further reasons to reject the panda argument. These stem from tensions between the panda argument, on the one hand, and some of Gould's other claims, on the other. The crucial point here is not simply that Gould's own view is internally conflicted, however. The first tension explored below applies to *any* thinker, religious or non-religious, who adopts Gould's compartmentalized approach to science and theology. The second tension applies in particular to atheists, agnostics, or anyone who believes that evolution is an unguided and unplanned process. A person who accepts either Gouldian compartmentalism or that evolution is undirected cannot also accept the panda's thumb argument. Rationally speaking, a person in this situation must make a choice. These considerations provide additional grounds for people in this situation to reject the panda argument.

10.1. Tension 1

The first internal tension concerns Gould's 'compartmental' approach to the relationship between science and religion. This doctrine, which he calls Non-Overlapping Magisteria (NOMA), sequesters science and religion from each other. He explains:

> To summarize. . . the net, or magisterium, of science covers the empirical realm: what is the universe made of (fact) and why does it work this way (theory). The magisterium of religion extends over questions of ultimate meaning and moral value. These two magisteria do not overlap. . . . To cite the old clichés, science gets the age of rocks, and religion the rock of ages; science studies how the heavens go, religion how to go to heaven. (Gould 1999, p. 6)

But if science and religion "do not overlap", then how can Gould's argument about a biological phenomenon, like the panda's thumb, rest upon theological claims? Indeed, in the panda argument, theological claims are *essential*. Remove these claims, and the argument's conclusion no longer follows validly from the premises. More generally, all of Gould's imperfection arguments—from zebra stripes to marsupial animals—turn upon God-talk. But if NOMA ought to be observed, then these arguments illicitly mix science and religion; as a result, they are illegitimate.

More generally, anyone who accepts an epistemic barrier between science and religion faces the same dilemma. Both compartmentalists and complementarians do so. The former assent to NOMA, while the latter believe that science and religion offer complementary perspectives on at least some of the same natural phenomena. Both generally hold that the content of a scientific theory cannot raise or lower a person's epistemic justification for a religious claim. So, too, the content of a religious claim cannot raise or lower a person's epistemic justification for a scientific theory. Yet in the panda argument, a theological claim purports to provide readers with increased justification for belief in evolutionary theory. Accordingly, compartmentalists and complementarians cannot coherently deploy the panda argument—or *any* of the many theology-laden arguments currently in play.

A similar result applies to methodological naturalists who reject God-talk in scientific discourse at the level of salient background beliefs, evidence, or arguments (Nelson 1996, pp. 493, 495–96, 514–15). They cannot coherently regard theology-laden arguments for evolution as properly scientific. They must choose *either* methodological naturalism *or* theology-laden scientific arguments for evolution. One cannot have it both ways (Dilley 2017).[37]

10.2. Tension 2

A second internal tension concerns the epistemic basis of Gould's theology. On what grounds can he legitimately know true propositions about God? The question becomes pressing in light of Gould's view of human evolution, in which humans were not created by God in order to know Him but were produced by mindless evolutionary processes (cf. Darwin 1958, pp. 92–93; Churchland 1987, pp. 548–49; Crisp 2016). In the late 1970s, Gould claimed that "mind, spirit, and God . . . are just words that express the wondrous results of neuronal complexity" (Gould 1977, p. 13). And ". . . if mind has no real existence beyond the brain, can God be anything more than an illusion invented by an illusion?" (Gould 1977, p. 25). That is, the notion that our 'minds' apprehend 'God's nature and ways' is akin to the notion that one illusion can reliably apprehend another illusion. The point here is not so much Gould's implied atheism (Sheldon 2014, p. 143), as it is his view of the human species' ability to reliably do theology. As late as 1999, just three years before his death, he endorsed the "cold bath" theory of nature. In this view, "[n]ature. . . existed for eons before we arrived, didn't know we were coming, and doesn't give a damn about us" (Gould 1999, p. 195). I take this as a metaphorical way of saying that humans are the result of indifferent natural forces; they are surely not creatures designed to inhabit the Earth by a self-revealing God.

In this light, one might wonder how Gould can reliably know certain claims about the deity. Gould avers that God would not (likely) create or allow suboptimal designs, yet, in his view, the human mind was never specifically designed to apprehend such truths. At most, humans were fashioned by chance and selection to survive and reproduce on the African savannah. How likely is it that homo sapiens, having ultimately arisen from primitive organisms, evolved cognitive powers to *know* true subjunctive claims about a (proposed) omnipotent deity's intentions for a tiny sliver of the biosphere—the panda's thumb—which is far removed from human survival and reproduction?[38] Of course, it is *possible* that our lineage evolved this ability. But is it *probable*? Gould's "cold bath" perspective suggests that the answer is either no or inscrutable. Accordingly, a critic may reasonably claim that Gould's view of evolution presents an obstacle to the justification of the panda argument's God-talk.

This same result applies to atheists and agnostics, for example, who make similar claims about human origins and the limitations of human cognition with respect to theological knowledge of the relevant sort. Such thinkers apparently have a defeater for *any positiva* argument for evolution. Insofar as they bring their own theology to the table—not borrowed from design rivals—then they need to justify this theology within the context of using it in an argument for evolution (or against design).[39] In this case, the version of evolution they accept opposes the very grounds they give for its acceptance. This is a troubling internal tension.

11. Final Thoughts

To be clear, this essay has not critiqued evolutionary theory or made a comprehensive case for it. Even if the difficulties that plague the panda argument apply to other theology-laden arguments for evolution,[40] it does not follow that there aren't *other* good arguments for evolutionary theory. The failure of one argument, or of one class of arguments, does not rule out the presence or power of different types of arguments.[41]

Instead, I have argued that a number of people are not rationally obligated to accept the panda's thumb argument, in either the deductive or likelihood formulations. Among other problems, Gould's argument maintains that the thumb is suboptimal for its primary purpose of stripping bamboo leaves. Not only does Gould offer no evidence for this claim, but prominent empirical studies indicate quite the opposite. Second, Gould's argument hinges on a particular claim about what the deity would (likely) do. Yet he provides no justification for this theological claim. As it happens, many religious believers who regard the natural world as adversely affected by the Fall have reason not to accept Gould's contention. More poignantly, some key thinkers directly involved in the origins discussion in the past, like Agassiz and Paley, as well as in the present, like young earth creationists and intelligent design theorists, have grounds to reject Gould's assertion to one degree or another.

Moreover, deep theological waters must be navigated if Gould is to hold that an imperfect thumb is *more* expected given evolution than given an omnipotent creator. Establishing this claim may require a careful examination of creaturely agency, divine intentions, and, in some circles, even doctrines of eschatology and the Incarnation. More generally, it is also no easy matter to establish what counts as 'imperfection' in the context of an "omnipotent creator". Such a being has an array of purposes available to Him. Discerning these is not trivial, yet rarely do such matters surface in discussions of the panda's thumb.

Whatever the case, any thinker—religious, atheist, agnostic, or otherwise—who accepts NOMA, complementarity, or methodological naturalism cannot also justifiably accept the panda argument. Indeed, they cannot justifiably accept any theology-laden arguments currently given for evolution within the context of science. As noted, such arguments are not limited to imperfection arguments but also include polemics that draw on molecular homology, gross anatomy, embryology, biogeography, paleontology, organic diversity, and the like. They appear not just in popular-level works but also in textbooks and elsewhere.

Perhaps more worrisome is whether Gould can have the relevant kind of theological knowledge in light of his own non-theistic vision of evolution. That is, can Gould (or others) reasonably expect to know specific subjunctive claims about a divine being's relationship to select episodes in organic history when such a being had nothing to do with humans' cognitive development? Something like this question troubled Darwin and, arguably, remains worrisome to the present day (Darwin 1958, pp. 92–93; Dilley 2012, pp. 51–52).

Stepping back, the panda's thumb is one of the most iconic arguments for evolutionary theory. Discussion of it raises significant challenges, especially regarding the nature of imperfection and the ways of the Almighty. More generally, from Darwin to Gould, atheists, agnostics, and theists have all contributed to theology-laden arguments for evolution. This is a rich topic, and much conversation remains ahead.

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Notes

1 Most notably, this includes Gould's critique of adaptationism, gene selection, and gradualism, not to mention his advocacy of punctuated equilibrium. Also fascinating are his clever rhetorical maneuvers in the "Darwin Wars." For the latter, see Sheldon (2014).

2 In addition, the icon is the namesake of the well-known pro-evolution website www.pandasthumb.org, accessed August 4, 2023.

3 Paul Nelson's fine article (1996), which I draw on in this essay, first drew my attention to the theological elements of Gould's argument.

4 There are a number of ways that the grounds for evolutionary theory extend beyond the scope of this article. For example, if it were demonstrated that complex biological systems, such as the bacterial flagellum or vertebrate eye, could be built by stepwise physical processes, then all things being equal, such data might be plausibly taken to confirm evolutionary theory over, say, intelligent design theory. Moreover, if the version of ID theory under consideration specifies a non-divine designer, rather than a supernatural designer, then theology-laden claims would not be required to argue in favor of evolution over intelligent design. Thus, in certain contexts, the grounds for evolution do not require God-talk. As such, the comprehensive case for evolution is in principle much broader than the particular theology-laden claims addressed in this essay. It is also notable that the standard definition of 'evolutionary theory' as 'common descent brought about by the mutation-selection mechanism (and other natural processes)' does not per se include theological content. The theory *itself* is not theology-laden (in the relevant sense) and, as just noted, in some contexts, *arguments* for it are likewise not theology-laden. Thus, one can speak coherently about evolutionary theory and some of its grounds in non-theological terms.

5 Of course, some other thinkers' theology-laden arguments for evolution involve much different theological claims than those examined in this article. The extent to which the present study applies to these arguments depends on these differences as well as various other factors.

6 See also Dilley and Tafacory (2019) for an analysis of the role of theology in arguments for evolution in 32 biology (and evolution) textbooks, including the top 12 in the United States. Luskin (2009, 2015) is also relevant.

7 I use the term 'special creation' in part because, as I will note below, Gould's own language suggests that he had something like this term in mind. It is arguably the case that Gould was influenced by his reading of the *Origin*. In that work, Darwin's chief rival seems to have been the view that God created the structures and organs of each species to be well-matched to their respective environments. Yet Darwin engaged with other versions of creationism as well. Indeed, part of the point of my argument (below) is that some of the actual contours of 19th century creationism were much broader and more nuanced than Gould's critique of 'special creation' (so defined). See also Gillespie (1979) and Hunter (2021a, 2021b).

8 On a related note, Cornelius Hunter (2007) argues that contemporary evolutionists who use theology in their polemic for evolution do not invent their own theology but rather draw upon a centuries-old tradition of secularized theology, which he calls "theological naturalism."

9 As we will see, the same can be said for even some creationists in the 19th century.

10 Gould italicizes the phrase.

11 In the original passage, Gould emphasizes that imperfect design is the failure of coordination between an organism and its current circumstances.

12 Although Gould here summarizes Darwin's argument, it is clear that Gould agrees with its substance.

13 The quoted words are Gould's.

14 The brackets are Gould's. He is quoting Davis.

15 My thanks to a reviewer for helping me formulate both deductive and likelihood versions of Gould's argument.

16 The quoted words are Gould's.

17 That is, empirical datum D favors hypothesis H_1 over hypothesis H_2 if and only if $Pr(D \mid H_1) > Pr(D \mid H_2)$. And the degree to which D favors hypothesis H_1 over hypothesis H_2 is given by the likelihood ratio $Pr(D \mid H_1) / Pr(D \mid H_2)$.

18 One might wonder if Gould thinks imperfections collectively, rather than individually, disprove the creation-in-the-present-form hypothesis. But Gould repeatedly emphasizes our ability to draw strong conclusions from *individual* entities (see Gould 1983, pp. 131, 258; 1986, p. 63; 2002, p. 104).

19 Some readers may wonder whether Gould had in mind a Bayesian formulation of the panda argument. My own view is that he did not. I have just noted his use of "proof" language (as opposed to probability). And, in the context of the panda's thumb or other imperfection arguments, it is not clear that he attended to prior probabilities, a core feature of Bayesian reasoning. In any case, some of the considerations below (about likelihoods) may be relevant to a Bayesian formulation of the probability of evolution given the suboptimal thumb, especially its catch-all likelihood.

[20] Although the authors state that the thumb arose in "mammalian evolution," they do not argue for the thumb's evolutionary origin but rather assume it, as per standard decorum in technical biology journals.

[21] Gould tends to emphasize the thumb's function for stripping bamboo leaves. Empirical studies show that the thumb also routinely handles bamboo in a manner that allows the panda to strip bark and to eat shoots and stalks as well.

[22] My thanks to a reviewer for suggesting some of these helpful questions.

[23] As we will see, the same is true for some 19th century creationists as well.

[24] According to New Testament scholar Douglas Moo (1996, pp. 513–14), the majority of modern commentators believe Saint Paul spoke directly about the adverse effects of the fall on creation in (Romans 8: 19–22). See also (Schreiner 1998, p. 435) and (Murray 1968, vol. 1, pp. 301–2).

[25] John Morris (2010), son of creationist godfather Henry Morris and president of the Institute for Creation Research, regards Snelling's 1500 page work (2010) as the sequel to *The Genesis Flood* (1961).

[26] Dembski (2009, p. 150) accepts the traditional view of God, including His omnipotence.

[27] Perhaps God does so via middle knowledge. In *The End of Christianity*, Dembski is not keen on the idea (2009, p. 216). Nonetheless, the concept is compatible with the thesis of his book.

[28] I will briefly examine Agassiz and Paley. I leave it to the reader to consult the views of Cuvier and Owen, who also held background beliefs that, given these beliefs, would have presumably allowed them to reject premise one of Gould's argument.

[29] In fact, according to Agassiz, humans can infer the existence of an intelligent Creator by considering the harmony of the "universe" as a whole, which arises from the relations between objects generally rather than from the adaptation of particular organisms to local environments.

[30] Among other claims about the divine, atheists or agnostics can be justified, in principle, in holding *conditional* claims about God. For example, nothing in their worldview precludes them in principle from accepting that "if an omnipotent creator made the panda's thumb, He would not (likely) have created or allowed it to be suboptimal." Such a claim does not entail belief in the existence of God but rather belief in what would follow *if* God existed. Similarly, atheists and agnostics can also hold that "the existence of a suboptimal panda's thumb is more expected given evolutionary theory than given an omnipotent creator". This claim likewise does not entail belief in the existence of God but rather an expectation about the datum *were* God to exist (relative to an expectation *were* evolutionary theory to be true). The general point, then, is that atheists or agnostics can, in principle, coherently accept some kinds of theology-laden claims, including some relevant to the contest between evolution and special creation. The main text simply observes that, whatever one's worldview, justifying such claims requires substantial reflection on a range of topics, including theological topics.

[31] A happy exception to this superficiality is Kitcher's careful *Living with Darwin* (2007). Plantinga (2011, pp. 55–63) offers a thoughtful critique of Kitcher's view.

[32] For a discussion about whether Sober's view has harmful implications for the justification of evolutionary theory, see Elliott Sober (2011a, 2011b), Sahotra Sarkar (2011), and Hunter (2014).

[33] It is worth noting that Sober himself thinks that his point is a two-edged sword. He argues that proponents of the design argument have the same problem: they do not have independent grounds to know the powers or plans of an intelligent designer and so cannot establish their likelihood claim (that, say, the human eye is probable given an intelligent designer). As Sober says, "we must be careful not to beg the question. We cannot reason that since the eye was made by God, that God must have wanted human beings to have eyes with the features we observe. What is needed is evidence about what God would have wanted the human eye to be like, where the evidence does not require a prior commitment to the assumption that there is a God and also does not depend on looking at the eye to determine its features" (Sober 2008, p. 146). For criticisms of Sober's view, see Dilley (2017). More importantly, Stephen Meyer's *Signature in the Cell* (2009) and *Darwin's Doubt* (2013) are perhaps the best biology-based design arguments available, yet they both utilize "inference to the best explanation" rather than a likelihood formulation. The same is true of Meyer's extended design argument for theism in *Return of the God Hypothesis* (2021). Moreover, in these works, Meyer shows how to make predictions (or set expectations) from a design perspective (e.g., Meyer 2009, appendix) and how to render the design argument in a Bayesian form (Meyer 2021, pp. 231–35).

[34] My thanks to a reviewer for this version of the objection (see Gould and Lewontin 1979; Vrba and Gould 1986; Gould 1983, pp. 147–57; 1989; 1991, pp. 109–39).

[35] Although Gould here summarizes Darwin's argument, it is clear from the context that Gould agrees with its substance.

[36] Even when evolutionists invoke theological claims with which creationists agree, like "God would not deceive", they generally apply them in ways not consonant with creationist theology (e.g., Dilley 2013, pp. 776–77).

[37] Arguably, the use of theology in arguments for evolution—from the *Origin* to the present day—stands in tension with the 'standard view' of the rise and normative establishment of methodological naturalism in biology. For the standard view, see Numbers (2003, pp. 279–85). For a counter, see Hunter (2007, 2021a, 2021b) and Dilley (2017).

[38] Assessing this claim is a complicated affair in part because one must non-arbitrarily choose the initial conditions (or time) from which to make the assessment (see Sober 2008, pp. 362–63).

[39] See Note 30.

[40] Moreover, some of the other theology-laden arguments for evolution involve much different theological claims than those examined in this article. This, too, limits the scope of my study.

[41] See also Note 4.

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