IN WILLIAM PALEY'S SHADOW: DARWIN'S EXPLANATION OF DESIGN

FRANCISCO J. AYALA

THE ARGUMENT-FROM-DESIGN

William Paley (1743-1805), the English clergyman, moralist, and theologian, was adamantly committed to the abolition of the slave trade and had become by the 1780s a much sought public lecturer against slavery. He was also an influential writer of works on Christian philosophy, ethics, and theocracy. *The Principles of Moral and Political Philosophy* (1785) and *A View of the Evidence of Christianity* (1794) earned him prestige and well-endowed ecclesiastical benefices, which allowed him a comfortable life. Illness forced him in 1800 to give up his public speaking career, which provided ample time to study science, particularly biology, and write *Natural Theology; or, Evidences of the Existence and Attributes of the Deity* (1802), the book by which he would become best known to posterity and which would greatly influence Darwin. With *Natural Theology*, Paley sought to update John Ray's *Wisdom of God Manifested in the Works of the Creation* (1691), taking advantage of one century of additional scientific knowledge.

Christian philosophers and theologians had argued, in the Middle Ages, that the functional organization of living beings evinces the existence of an Omnipotent and Omniscient Designer. In the thirteenth century, Saint Thomas Aquinas had used an argument-from-design as his "fifth way" to demonstrate the existence of God. Aquinas' argument was based on the "harmony" of the universe and all its parts. In the years following Paley's *Natural Theology*, between 1833 and 1840, eight *Bridgewater Treatises* were written by eminent scientists and philosophers to set forth the "the Power, Wisdom, and Goodness of God as manifested in the Creation." The mechanisms and vital endowments of the human hand incontrovertibly manifest, according to Sir Charles Bell, author of one *Bridgewater Treatise*, that the hand has been designed by the same omniscient Power that created the world.

Department of Ecology and Evolutionary Biology, University of California, Irvine, CA 29697, USA. / fjayala@uci.edu

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Paley's keystone claim is that "There cannot be design, without a designer; contrivance, without a contriver; order, without choice; means suitable to an end, and executing their office in accomplishing that end, without the end ever having been contemplated"[1] (*Natural Theology*, pp. 15-16). *Natural Theology* is a sustained argument manifesting the obvious design of humans and their organs, limbs and component parts, as well as the design of all sorts of organisms, in themselves and in their relations to one another and to their environment. There are chapters dedicated to the complex design of the human eye; to the human frame, which displays a precise mechanical arrangement of bones, cartilage, and joints; to the circulation of the blood and the disposition of blood vessels; to the comparative anatomy of humans and animals; to the digestive system, kidneys, urethras, and bladder; to the wings of birds and the fins of fish, and much more. For 352 pages, *Natural Theology* conveys Paley's expertise: extensive and accurate biological knowledge, as detailed and precise as it was available in the year 1800. After detailing the precise organization and exquisite functionality of each biological object or process, Paley draws again and again the same conclusion: that only an Omniscient and Omnipotent Deity could account for these marvels of mechanical perfection, purpose, and functionality, and for the enormous diversity of inventions that they entail.

Paley's first model example is the human eye, in chapter III, "Application of the Argument." Comparing the complexity of a telescope and an eye, he argues that "there is precisely the same proof that the eye was made for vision as there is that the telescope was made for assisting it" (p. 20). He summarizes his argument as follows:

> [We marvel] knowing as we do what an eye comprehends, namely, that it should have consisted, first, of a series of transparent lenses—very different, by the by, even in their substance, from the opaque materials of which the rest of the body is, in general at least, composed, and with which the whole of its surface, this single portion of it excepted, is covered: secondly, of a black cloth or canvas [the retina]—the only membrane in the body which is black—spread out behind these lenses, so as to receive the image formed by pencils of light transmitted through them; and placed at the precise geometrical distance at which, and at which alone, a distinct image could be formed, namely, at the concourse of the refracted rays: thirdly, of a large nerve communicating between this membrane and the brain; without which, the action of light upon the membrane, however modified by the organ, would be lost to the purposes of sensation (p. 48).

Could the eye have come about without design or preconceived purpose, as a result of chance? Paley had set the argument against chance, in the very first paragraph of *Natural Theology*, arguing rhetorically by analogy

with a watch, that "when we come to inspect the watch, we perceive that its several parts are framed and put together for a purpose, *e.g.*, that they are so formed and adjusted as to produce motion, and to point out the hour of the day" (p. 1).

The strength of the argument against chance derives, Paley tells us, from what he names "relation," a notion akin to what contemporary anti-evolutionists have named "irreducible complexity" (and that some of them have given themselves credit for its discovery). This is how Paley formulates the argument. "When several different parts contribute to one effect, or, which is the same thing, when an effect is produced by the joint action of different instruments, the fitness of such parts or instruments to one another for the purpose of producing, by their united action, the effect, is what I call *relation*; and wherever this is observed in the works of nature or of man, it appears to me to carry along with it decisive evidence of understanding, intention, art" (pp. 175-176). The outcomes of chance do not exhibit relation among the parts or, as we might say, organized complexity.

Paley's argument-from-design collapses when he seeks to account for the imperfections, defects, pain, and cruelty that pervade the living world. One can admire his biological knowledge in this respect and his honesty in facing the issue. His general explanation for nature's imperfections is that "Irregularities and imperfections are of little or no weight [...], they are to be taken in conjunction with the unexceptionable evidences which we possess of skill, power, and benevolence displayed in other instances" (p. 46). But if functional design manifests an intelligent designer, why should not deficiencies indicate that the designer is less than omniscient, or less than omnipotent, or less than benevolent? Paley cannot have it both ways. Moreover, we know that some deficiencies are not just imperfections, but they are outright dysfunctional, jeopardizing the very function the organ or part is supposed to serve. We now know, of course, that the explanation for dysfunction and imperfection is natural selection, which can account for design and functionality, but does not achieve any sort of perfection, nor is it omniscient, omnipotent, or benevolent.

DARWIN'S DISCOVERY: DESIGN WITHOUT DESIGNER

Charles Darwin's (1809-1882) *On the Origin of Species* (1859) is generally valued as the first sustained and convincing argument demonstrating the evolution of organisms. This is, of course, correct. But accumulating evidence for common descent with diversification may very well have been a subsidiary objective of Darwin's masterpiece. There is a possible reading of Darwin's *Origin of Species* that sees it, first and foremost, as a sustained effort to solve Paley's problem of how to account for the design of organ-

isms within a scientific explanatory framework. This is, indeed, how I interpret Darwin's *Origin*. The Introduction and chapters I through VIII explain how natural selection accounts for the adaptations and behaviors of organisms, their "design." The extended argument starts in chapter I, where Darwin describes the successful selection of domestic plants and animals and, with considerable detail, the success of pigeon fanciers seeking exotic "sports." This evidence manifests what selection can accomplish using spontaneous variations beneficial to man. The ensuing chapters extend the argument to variations propagated by natural selection (*i.e.*, reproductive success) for the benefit of the organisms, rather than by artificial selection of traits desirable to humans. Organisms exhibit design, but it is not "intelligent design," imposed by God as a Supreme Engineer, but the result of natural selection promoting the adaptation of organisms to their environments. Organisms exhibit complexity, but it is not "irreducible complexity," emerged all of a sudden in its current elaboration, but it has arisen gradually and cumulatively, step by step, promoted by the adaptive success of individuals with incrementally more complex elaborations.

If Darwin's explanation of the adaptive organization of living beings is correct, evolution necessarily follows as a consequence of organisms becoming adapted to different environments in different localities and to the ever changing conditions of any given environment, and as hereditary variations become available at a particular time that improve the organisms' chances of survival and reproduction. The *Origin's* evidence for biological evolution is central to Darwin's explanation of "design," because his explanation requires the occurrence of biological evolution, which he therefore seeks to demonstrate in most of the remainder of the book (chapters IX-XIII), returning to the original theme in the concluding chapter XIV. In the last paragraph of the *Origin*, Darwin eloquently returns, indeed, to the dominant theme of adaptation or design:

> It is interesting to contemplate an entangled bank, clothed with many plants of many kinds, with birds singing on the bushes, with various insects flitting about, and with worms crawling through the damp earth, and to reflect that these *elaborately constructed* forms, *so different* from each other, and dependent on each other *in so complex a manner*, have all been produced by laws acting around us. [...] Thus, from the war of nature, from famine and death, the most exalted object which we are capable of conceiving, namely, the production of the higher animals, directly follows. There is grandeur in this view of life, with its several powers, having been originally breathed into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning *endless forms most beautiful and most wonderful* have been, and are being, evolved (*Origin*, p. 489-490, emphasis added).

Darwin addresses the same issue as Paley: how to account for the adaptive configuration of organisms, the obvious "design" of their parts to fulfill certain functions. Darwin argues that hereditary adaptive variations ("variations useful in some way to each being") occasionally appear, and that these are likely to increase the reproductive chances of their carriers. The success of pigeon fanciers and animal breeders clearly evinces the occasional occurrence of useful hereditary variations. Over the generations, favorable variations will be preserved, multiplied and conjoined; injurious ones will be eliminated. In one place, Darwin adds: "I can see no limit to this power [natural selection] in slowly and beautifully *adapting* each form to the most complex relations of life" [2]. Natural selection was proposed by Darwin primarily to account for the adaptive organization, or "design," of living beings; it is a process that preserves and promotes adaptation. Evolutionary change through time and evolutionary diversification (multiplication of species) are not directly promoted by natural selection (hence, the so-called evolutionary stasis emphasized by the theory of punctuated equilibrium), but they often ensue as by-products of natural selection fostering adaptation.

NATURAL SELECTION

The current understanding of the principle of natural selection is formulated in genetic and statistical terms as differential reproduction. Natural selection implies that some genes and genetic combinations are transmitted to the following generations with a higher probability than their alternates. Such genetic units will become more common in subsequent generations and their alternates less common. Natural selection is a statistical bias in the relative rate of reproduction of alternative genetic units.

In *Natural Theology* William Paley considered and rejected a hypothesis combining chance and natural selection as processes that might jointly account for the design of organisms.

> The hypothesis teaches, that every possible variety of being hath, at one time or other, found its way into existence—by what cause or in what manner is not said—and that those which were badly formed perished [...] What should we think of a man who, because we had never ourselves seen watches, telescopes, stocking-mills, steam-engines, etc., made, knew not how they were made, nor could prove by testimony when they were made, or by whom, would have us believe that [...] a mass of metals and other materials having run, when melted, into all possible figures, and combined themselves in all possible forms and shapes and proportions, these things which we see are what were left from the incident (*Natural Theology*, p. 51).

This hypothesis is reminiscent of the philosopher of classic Greece Empedocles' account of the origin of complex entities, such as animals and plants, and it seems similar to the model of chance and selection rejected by some contemporary anti-evolutionists, but it has nothing significant in common with Darwin's theory of natural selection, an incremental process that incorporates adaptive changes, one small step at a time, in response to the environmental circumstances of the organisms.

Natural selection, as discovered by Darwin, does not operate in the manner of Paley's unacceptable hypothesis, acting on randomly formed organisms, allowing the functional ones to survive while the great majority die. Natural selection does not operate, either, as a sieve that retains the rarely arising useful genes and lets go the more frequently arising harmful mutants; at least, not only. Natural selection acts in the filtering way of a sieve, but it is much more than a purely negative process, for it is able to generate novelty by increasing the probability of otherwise extremely improbable genetic combinations. Natural selection is thus a creative process. It does not "create" the entities upon which it operates, but produces adaptive (functional) genetic combinations that could not have existed otherwise.

The creative role of natural selection must not be understood in the sense of the "absolute" creation that traditional Christian theology predicates of the Divine act by which the universe was brought into being *ex nihilo,* or in the manner of creation in which Paley assumes God, the Supreme Engineer that had created the adaptations of organisms. Natural selection may rather be compared to a painter who creates a picture by mixing and distributing pigments in various ways over the canvas. The canvas and the pigments are not created by the artist but the painting is. It is inconceivable that a random combination of the pigments might result in the orderly and complex whole of a work of art, such as Rembrandt's *Night Watch*. In the same way, the combination of genetic units that carries the hereditary information responsible for the formation of the vertebrate eye could have never been produced by a random process like mutation. Not even if we allow for the three-billion-years-plus during which life has existed on earth. The complicated anatomy of the eye like the exact functioning of the kidney are the result of a nonrandom process—natural selection.

Critics have sometimes alleged as evidence against Darwin's theory of evolution examples showing that random processes cannot yield meaningful, organized outcomes. It is thus pointed out that a series of monkeys randomly striking letters on a typewriter would never write *The Origin of Species*, even if we allow for millions of years and many generations of monkeys pounding at typewriters.

This criticism would be valid if evolution would depend only on random processes. But natural selection is a non-random process that promotes adaptation by selecting combinations that "make sense," *i.e.*, that are useful to the organisms. The analogy of the monkeys would be more appropriate if a process existed by which, first, meaningful words would be chosen every time they appeared on the typewriter; and then there would also be typewriters with previously selected words rather than just letters in the keys, and again there would be a process to select meaningful sentences every time they appeared in this second typewriter. If every time words such as "the," "origin," "species," and so on, appeared in the first kind of typewriter, they each became a key in the second kind of typewriter, meaningful sentences would occasionally be produced in this second typewriter. If such sentences became incorporated into keys of a third type of typewriter, in which meaningful paragraphs were selected whenever they appeared, it is clear that pages and even chapters "making sense" would eventually be produced. The end product would be an "irreducibly complex" text.

We need not carry the analogy too far, since the analogy is not fully satisfactory, but the point is clear. Evolution is not the outcome of purely random processes, but rather there is a "selecting" process, which picks up adaptive combinations because these reproduce more effectively and thus become established in populations. These adaptive combinations constitute, in turn, new levels of organization upon which the mutation (random) plus selection (non-random or directional) process again operates. The complexity of organization of animals and plants is "irreducible" to simpler components in one or very few steps, but not thorough the millions and millions of generations and the multiplicity of steps and levels made possible by eons of time.

CHANCE AND NECESSITY

The critical point is that evolution by natural selection is an incremental process, operating over eons of time and yielding organisms better able to survive and reproduce than others, which typically differ from one another at any one time only in small ways; for example, the difference between producing more or fewer progeny or between having or lacking an enzyme able to catalyze the synthesis of one particular aminoacid. Notice also that increased complexity is not a necessary outcome of natural selection, although complexity increases from time to time in some lineages of descent, so that, although rare, they are very conspicuous over time's eons. That is, increased complexity is not a necessary consequence of evolution by natural selection, but rather emerges occasionally as a matter of statistical bias. The longest living organisms on Earth are the

microscopic bacteria, which have continuously existed on our planet for three and a half billion years and yet exhibit no greater complexity than their old time ancestors. More complex organisms came about much later, without the elimination of their simpler relatives. For example, the primates appeared on earth some fifty million years ago and our species, *Homo sapiens*, came about two hundred thousand years ago.

There is an important respect in which an artist makes a poor analogy of natural selection. A painter or a sculptor has a preconception of what he or she wants to paint and will consciously modify the painting or sculpture so that it represents what the artist wants. Natural selection has no foresight, nor does it operate according to some preconceived plan. Rather it is a purely natural process resulting from the interacting properties of physicochemical and biological entities. Natural selection is simply a consequence of the differential multiplication of living beings, as pointed out. It has some appearance of purposefulness because it is conditioned by the environment: which organisms reproduce more effectively depends on what variations they possess that are useful in the place and at the time where the organisms live. But natural selection does not anticipate the environments of the future; drastic environmental changes may be insuperable to organisms that were previously thriving. Species extinction is the common outcome of the evolutionary process. The species existing today represent the balance between the origin of new species and their eventual extinction. More than 99 percent of all species that ever lived on earth have become extinct without issue. These may have been more than one billion species; the available inventory of living species has identified and described less than two million out of some ten million estimated to be now in existence.

The team of typing monkeys is also a bad analogy of evolution by natural selection, because it assumes that there is "somebody" who selects letter combinations and word combinations that make sense. In evolution there is no one selecting adaptive combinations. These select themselves because they multiply more effectively than less adaptive ones.

The process of natural selection can explain the adaptive organization of organisms, as well as their diversity and evolution, as a consequence of their adaptation to the multifarious and ever changing conditions of life. The fossil record shows that life has evolved in a haphazard fashion. The radiations, expansions, relays of one form by another, occasional but irregular trends, and the ever-present extinctions, are best explained by natural selection of organisms subject to the vagaries of genetic mutation and environmental challenge. The scientific account of these events does not necessitate recourse to a preordained plan, whether imprinted from without by an omniscient and all-powerful Designer, or resulting from some immanent force driving the process towards definite outcomes.

Biological evolution differs from a painting or an artifact in that it is not the outcome of preconceived design.

Natural selection accounts for the "design" of organisms, because adaptive variations tend to increase the probability of survival and reproduction of their carriers at the expense of maladaptive, or less adaptive, variations. The arguments of Paley against the incredible improbability of chance accounts of the adaptations of organisms are well taken as far as they go. But neither Paley nor any other author before Darwin was able to discern that there is a natural process (namely, natural selection) that is not random, but rather is oriented and able to generate order or "create." The traits that organisms acquire in their evolutionary histories are not fortuitous but determined by their functional utility to the organisms, "designed" as it were to serve their life needs.

Chance is, nevertheless, an integral part of the evolutionary process. The mutations that yield the hereditary variations available to natural selection arise at random, independently of whether they are beneficial or harmful to their carriers. But this random process (as well as others that come to play in the great theatre of life) is counteracted by natural selection, which preserves and multiplies what is useful and eliminates the harmful. Without hereditary mutation, evolution could not happen because there would be no variations that could be differentially conveyed from one to another generation. But without natural selection, the mutation process would yield disorganization and extinction because most mutations are disadvantageous. Mutation and selection have jointly driven the marvelous process that starting from microscopic organisms has yielded orchids, birds, and humans.

The theory of evolution conveys chance and necessity jointly intricated in the stuff of life; randomness and determinism interlocked in a natural process that has spurted the most complex, diverse, and beautiful entities in the universe: the organisms that populate the earth, including humans who think and love, endowed with free will and creative powers, and able to analyze the process of evolution itself that brought them into existence. This is Darwin's fundamental discovery, that there is a process that is creative though not conscious, a process that creates design without necessitating a Designer [3].

IN PRAISE OF IMPERFECTION

When confronted with the cruelties, imperfections and dysfunctions commonly found in the living world, Paley advances a defense of the argument-from-design that is unsatisfactory. It is evasive to say of imperfections and deficiencies that "they are of little or no weight", or that "apparent blemishes ought to be referred to some cause, though we be ignorant of it"

(*Natural Theology*, p. 46). Michael J. Behe, who has reformulated Paley's argument-from-design, makes a similarly evasive claim: "Clearly, designers who have the ability to make better designs do not necessarily do so... The argument from imperfection overlooks the possibility that the designer might have multiple motives, with engineering excellence oftentimes relegated to a secondary role" (Behe 1996, p. 223).

But this will not do. Behe's account is not only evasive, but it totally destroys his claim that intelligent design is a scientific hypothesis, because it provides it with an empirically impenetrable shield. If we cannot reject intelligent design because the designer may have reasons that we could not possibly ascertain, there would seem to be no way to test intelligent design. Scientific hypotheses are tested by interrogating nature about predictions logically derived from the hypothesis that are expected to be observed in the world of experience. But it follows from Behe's evasion that we cannot draw out any predictions that could possibly falsify the hypothesis of intelligent design. Intelligent design as an explanation for the adaptations of organisms could be (natural) theology, as Paley would have it, but, whatever it is, it would not be a scientific hypothesis, because there is no way of ascertaining whether it is false by showing the falsity of its logically necessary consequences.

Moreover, the issue is not only that organisms and their parts are less than perfect, but also that deficiencies and dysfunctions are pervasive, evidencing defective "design." Consider the human jaw. We have too many teeth for the jaw's size, so that wisdom teeth need to be removed and orthodontists make a decent living straightening the others. Would we want to blame God for such defective design? A human engineer could have done better. Evolution gives a good account of this imperfection. Brain size increased over time in our ancestors, and the remodeling of the skull to fit the larger brain entailed a reduction of the jaw. Evolution responds to the organisms' needs through natural selection, not by optimal design but by "tinkering," as it were, by slowly modifying existing structures. Consider now the birth canal of women, much too narrow for easy passage of the infant's head, so that thousands upon thousands of babies die during delivery. Surely we don't want to blame an Intelligent Designer for this defective design or for the children's deaths. Science makes it understandable, a consequence of the evolutionary enlargement of our brain. Females of other primates do not experience this difficulty.

Examples of deficiencies and dysfunctions in all sorts of organisms can be endlessly multiplied, reflecting the opportunistic, tinkerer-like character of natural selection, rather than intelligent design. The world of organisms also abounds in characteristics that might be called "oddities," as well as those that have been characterized as "cruelties," an apposite qualifier if the cruel behaviors were designed outcomes of a being holding on to

human or higher standards of morality. But the "cruelties" of biological nature are only metaphoric "cruelties" when applied to the outcomes of natural selection.

Examples of "cruelty" involve not only the familiar predators (say, a chimpanzee) tearing apart their prey (say, a small monkey held alive by a chimpanzee biting large flesh morsels from the screaming monkey), or parasites destroying the functional organs of their hosts, but also, and very abundantly, between organisms of the same species, even between individuals of different sexes in association with their mating. A well-known example is the female praying mantis that devours the male after coitus is completed. Less familiar is that, if she gets the opportunity, the female will eat the head of the male *before* mating, which thrashes the headless male mantis into spasms of "sexual frenzy" that allow the female to connect his genitalia with hers [4]. In some midges (tiny flies), the female captures the male as if he were any other prey and with the tip of her proboscis she injects into his head her spittle that starts digesting the male's innards that are then sucked by the female; partly protected from digestion are the relatively intact male organs that break off inside the female and fertilize her [5]. Male cannibalism is known in dozens of species, particularly spiders and scorpions. Diverse sorts of oddities associated with mating behavior are described in the delightful, but accurate and documented, book by Olivia Judson, *Dr. Tatiana's Sex Advice to All Creation* (2002).

Some proponents of the argument-from-design, including Behe, claim, at times, that their hypothesis is scientific, because postulating an "Intelligent Designer" does not implicate any supernatural causes, such as God. But this is dissembling. William Paley and Thomas Aquinas were adamant that the conclusion of the argument-from-design was the existence of an Omnipotent, Omniscient, and Benevolent God. But current biology has disclosed that the argument misfires. As the distinguished American philosopher, David Hull, has pointed out:

> What kind of God can one infer from the sort of phenomena epitomized by the species on Darwin's Galapagos Islands? The evolutionary process is rife with happenstance, contingency, incredible waste, death, pain and horror... Whatever the God implied by evolutionary theory and the data of natural selection may be like, he is not the Protestant God of waste not, want not. He is also not the loving God who cares about his productions. He is not even the awful God pictured in the Book of Job. The God of the Galapagos is careless, wasteful, indifferent, almost diabolical. He is certainly not the sort of God to whom anyone would be inclined to pray [6].

CODA

Ernst Mayr's contributions to evolutionary theory and to the philosophy and history of biology are stupendous, in that they are so very numerous,

embrace so many subjects, and excel beyond expectation. Over forty years I have learned much from his books and other writings and have been privileged to be considered his friend. I have selected the topic for this paper for two reasons. One is that the topic of adaptation and the historiography of Darwin have been Mayr's subjects of sustained interest for many years. The other reason is circumstantial. In late 2003 and early 2004, Mayr and I corresponded about the very subject of this paper: William Paley's *Natural Theology* and its influence on Darwin's writings. On 18 February 2004, Mayr wrote to me "I enjoyed your paper on Intelligent Design (Ayala 2003)... The verbal excerpts from Paley are quite wonderful. I never read Paley in the original and this opened my eyes! And it shows how well aware Darwin was that Paley could be answered. In the *Origin* (and perhaps even better in the orchid book) Darwin shows again and again how wrong it is to consider the world a product of Intelligent Design." I dedicate this paper to Ernst Mayr, on the occasion of his one hundredth anniversary, with unflagging admiration and respect.

NOTES

1 William Paley, *Natural Theology* (New York: American Tract Society). I will cite pages following this American edition, which is undated, but seems to have been printed in the late nineteenth century.

2 In his autobiography, Darwin wrote, "The old argument of design in nature, as given by Paley, which formerly seemed to me so conclusive, falls, now that the law of natural selection has been discovered. We can no longer argue that, for instance, the beautiful hinge of a bivalve shell must have been made by an intelligent being, like the hinge of a door by a man." See Barlow (1958).

3 I have further developed the points made in this section in Ayala (1999). For a fuller discussion of Paley's argument-from-design see Ayala (2003).

4 Lawrence (1992); Elgar (1992).

5 Downes (1978).

6 Hull (1992). The great Argentine fabulist Jorge Luis Borges conveys an utterly pessimistic view of the world by quoting the damming words of Ugbar's sage: "Mirrors and fatherhood are abominable because they multiply and disseminate the universe." The second century AD Gnostic Basilides would have approved of science's exclusion of God from misshapen creation, as he wrote: "What greater glory for a God than to be absolved of the world?" (Quoted in Bloom 2002, p. 682). See also Ayala (2003).

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