Essay Reviews

Evolution vs. Creationism

Francisco J. Ayala

Department of Ecology and Evolutionary Biology
University of California
Irvine, CA 92697, U.S.A.


Creation vs. Creationism

It is unfortunate that the anti-evolution movement in the United States, as well as elsewhere, has successfully appropriated the term 'creationism' as its banner. One meaning of the term 'creationism' is shared by most religious believers, namely, the notion that the world was created by God ex nihilo, from nothing. This belief, in itself, does not deny, nor does it affirm, the evolution of life. Reciprocally, science has nothing to say about the assertion that God created the universe ex nihilo, because this is a religious belief that concerns the supernatural. The supernatural, as well as questions about values and about the meaning and purpose of life, transcend science, they are beyond its scope.

Astrophysicists have discovered the expansion of the universe and some have concluded that there was a Big Bang, a 'singularity', at which the known universe started from a single point in space and in time, about 14 billion years ago. So, religious believers say, there was nothing before the Big Bang, which 'proves' that science has confirmed the creation of the world by God. But science has not done, it cannot do, anything of the kind. What religious believers are entitled to assert is that the Big Bang is consistent with creation by God. This compatibility is enough, and should be enough, for the believer. Seeking confirmation
of religious faith in science is the wrong road to take and, indeed, a dangerous one.

The most distinctive feature of science is that it formulates hypotheses that can be tested by examining whether predictions about the world of experience derived from a hypothesis are indeed the case. The events predicted, in order to have confirmatory value, must be unknown at the time the prediction is derived from the hypothesis. Yet, what unknown predictions can we derive from the ‘hypothesis’ of creation by God? None whatsoever. That the world started to expand (exist?) at a certain moment is something already known, it is what we want to explain. Any other possible predictions concern either (1) ‘nothing’, the absence of any physical reality before the creation event, or (2) God, a supernatural being, which transcends the natural world of experience.

**Versions of Creationism**

The term ‘creationism’ has become used, at least but not only in the United States, to refer to religious-based anti-evolution statements. There are many versions of creationism. In *Evolution vs. Creationism*, Eugenie C. Scott distinguishes seven shades of creationism within a ‘creation/evolution’ continuum (p. 57). The three most distinctive forms of creationism are the following:

**Young-Earth creationism** (YEC) interprets literally the six-day narrative of creation and other events in *Genesis*. The creation of the world is about 6,000 years old, dated to the year 4004 B.C., according to the Irish Archbishop James Ussher (1581-1656), calculated by adding the ages of the patriarchs and taking into account other biblical dates. Young-earth creationists assert that Noah’s Flood was universal and happened as described in *Genesis*. The Institute for Creation Research in San Diego, California, is one notable center of young-earth creationism. It has a museum, publications, and academic activities.

One version of YEC is ‘flat-earth creationism’, which asserts that the earth is flat with rounded edges, shaped like a coin, not like a sphere. The International Flat Earth Research Society of Lancaster, California, counts 3500 members, according to a recent inventory.

Another version of YEC is ‘geocentrism’, which accepts that the earth is shaped like a sphere and asserts that it is the center of the solar system, around which revolve the sun and the other planets.
As Scott points out (p. 58), a plenary session at the 1985 conference of the Bible-Science Association consisted of a debate between two geocentrist and two heliocentrist.

*Old-Earth creationism* (OEC) accepts that the earth is ancient, as concluded by astrophysics, geology, biology, and other scientific disciplines. The Catholic Church, the Church of England, and many protestant churches have accepted, at least for the last two or three centuries, the old age of the universe. There are several variations of OEC, such as ‘Gap Creationism’, ‘Day-Age Creationism’, and ‘Progressive Creationism’ (pp. 61-63). According to Day-Age creationists, the ‘days’ of the *Genesis* narrative of creation are long-periods of time or ‘ages’. Distinctive of some OEC is the belief in successive interventions of God, who separately created the world as well as all living creatures, in stages.

*Intelligent-Design Creationism* (IDC). The argument-from-design seeking to demonstrate the existence of God, based on the complexity and diversity of life, has a long tradition in Christian history. In *The Wisdom of God Manifested in the Works of Creation* (1691), John Ray buttressed the argument with scientific information. William Paley in *Natural Theology* (1802) used his extensive biological knowledge to argue repeatedly and cleverly that organisms and their features manifest that they have been specifically designed to fulfill certain functions or purposes. Contemporary ID creationists often accept evolution: that organisms, including humans, have evolved from ancestors that were different from them. But ID creationists argue that some features, such as the vertebrate eye, or the blood-clotting mechanism of mammals, or the bacterial flagellum, are too complicated so that they cannot have arisen by natural processes. In this version of ID, God intervenes from time to time in the evolutionary process in order to create these complex features.

**Biblical Fundamentalism**

Biblical fundamentalists, although a minority of Christians, have periodically gained considerable public and political influence in the United States and are extending their influence in other countries as well. Their literal interpretation of the Bible motivates their opposition to the teaching of the theory of evolution in the public schools. Biblical fundamentalism in the United States and its opposition to evolution can largely be traced to two movements with
19th-century roots, Seventh-day Adventism and Pentecostalism. Seventh-day Adventists insist on the recent creation of life and the universality of the Flood, which they believe deposited the fossil-bearing rocks. This distinctively Adventist interpretation of Genesis became the hard core of ‘creation science’ in the late 20th century and was incorporated into the ‘balanced-treatment’ laws of the states of Arkansas and Louisiana. Many Pentecostals, who generally endorse a literal interpretation of the Bible, also have adopted and endorsed the tenets of creation science, including the recent origin of earth and a geology interpreted in terms of the Flood.

During the 1920s, biblical fundamentalists in the United States helped influence more than 20 state legislatures to debate antievolution legislation, and four states - Arkansas, Mississippi, Oklahoma, and Tennessee - prohibited the teaching of evolution in their public schools. A spokesman for the antievolutionists was William Jennings Bryan, three times the unsuccessful Democratic candidate for the U.S. presidency, who said in 1922, ‘We will drive Darwinism from our schools’. In 1925 Bryan took part in the prosecution of John T. Scopes, a high-school teacher in Dayton, Tennessee, who had admittedly violated the state’s law forbidding the teaching of evolution.

In 1968 the Supreme Court of the United States declared unconstitutional any law banning the teaching of evolution in public schools. Thereafter, Christian fundamentalists introduced legislation in a number of state legislatures ordering that the teaching of ‘evolution science’ be balanced by allocating equal time to ‘creation science’. Creation science, it was asserted, propounds that all kinds of organisms abruptly came into existence when God created the universe, that the world is only a few thousand years old, and that the biblical Flood was an actual event that only one pair of each animal species survived. In the early 1980s Arkansas and Louisiana passed statutes requiring the balanced treatment of evolution science and creation science in their schools, but opponents successfully challenged the statutes as violations of the constitutionally mandated separation of church and state.

The Arkansas statute was declared unconstitutional in federal court after a public trial in Little Rock. The Louisiana law was appealed all the way to the Supreme Court of the United States, which in 1987 ruled Louisiana’s ‘Creationism Act’ unconstitutional, because by advancing the religious belief that a supernatural being created humankind, which is embraced by the phrase creation science, the act impermissibly endorses religion.
Intelligent Design

The most recent confrontation between creationism and the theory of evolution in the courts of law involves the concept of intelligent design (ID), which in its current formulation came into existence after the Supreme Court’s decision of 1987 that creation science could not be taught in the public schools. Scott dedicates chapter 6 (pp. 113-133) to describe the ID movement and to criticize it. Evolution vs. Creationism was, however, published before the Dover decision of 20 December 2005, in which Federal Judge John E. Jones III declares that ‘the Defendants’ ID Policy violates the Establishment Clause of the First Amendment of the Constitution of the United States’ and, therefore, the ‘Defendants are permanently enjoined from maintaining the ID Policy in any school within the Dover Area School District’.

The strongest possible case for intelligent design ever made is Natural Theology (1802) by William Paley, a book that Darwin read and much appreciated while he was a student at Cambridge University. Paley’s ID arguments were based on extensive and accurate biological knowledge, as extensive and accurate as it was available at the time. Paley made the case that the human eye is as complex a contrivance as a watch or a telescope, with several parts all required to fit precisely for achieving vision. He explored the diversity of organs and limbs in all sorts of organisms, precisely designed to accomplish their function. Paley saw that the relations between mates of the same species, between animals of different species, and between organisms and their environments, evinced to have been precisely designed by an omnipotent Creator. The argument from intelligent design has never been made, neither before nor afterwards, as extensively or as forcefully as it was made by Paley. In the first half of the nineteenth century, other British scientists would explore scientific evidence of intelligent design, such as, for example, Sir Charles Bell in The Hand, Its Mechanisms and Vital Endowments as Evincing Design. Paley’s and Bell’s evidence for design was convincing and, indeed, definitive on the basis of scientific knowledge available in the first half of the nineteenth century. Their arguments crumbled, of course, after the discovery of natural selection by Charles Darwin and the publication of On the Origin of Species in 1859.

In the 1990s, several authors in the United States have revived the ID argument, notably Michael Behe, William Dembski, and Phillip Johnson, among others. These authors assert that organisms are so complex that no natural process could account for their origin; rather the organisms and their parts evince that they have been designed to fulfill certain functions. Natural selection, they argue, cannot account for the
design of complex features, such as the human eye, the immune system of mammals, or the flagellum of bacteria.

These new creationists are persuaded that the theory of evolution is antagonistic to their religious beliefs and would like to discover God and faith in science. I rather see that religious beliefs should seek justification on the solid rocks of faith and revelation, not on scientific knowledge - which by its very nature is never definitive or forever valid.

Scott discusses and ably refutes a variety of spurious criticisms raised by the newer proponents of ID, notably that evolution is 'only' a theory. But 'theory' is a term used by scientists to refer to well-established knowledge, such as the molecular theory of matter, the heliocentric theory of planet revolutions, or relativity theory. When scientists talk about the 'theory' of evolution, they use the word differently than people do in ordinary speech. In everyday speech, theory often means 'guess' or 'hunch'. In science, however, a theory is a well-substantiated explanation of some aspect of the natural world that incorporates observations, facts, laws, inferences, and tested hypotheses. Scientists refer to conjectures as 'hypotheses'.

The call for an intelligent designer is predicated by ID proponents on the existence of 'irreducible complexity' in organisms. An irreducibly complex system is defined by Michael Behe as an entity 'composed of several well-matched, interacting parts that contribute to the basic function, wherein the removal of any one of the parts causes the system to effectively cease functioning'. Intelligent-design proponents argue that irreducibly complex systems cannot be the outcome of evolution, because they cannot be produced by slight, successive modifications of a precursor system, because any precursor to an irreducible complex system that is missing a part is by definition nonfunctional. In other words, unless all parts of the eye come simultaneously into existence, the eye cannot function; it does not benefit a precursor organism to have just a retina, or a lens, if the other parts are lacking.

The human eye, according to this argument, could not have evolved one small step at a time, in the piecemeal manner by which natural selection works. But evolutionists have pointed out, again and again, with supporting evidence, that organs and other components of living beings are not irreducibly complex - they do not come about suddenly. Evolutionists have shown that the organs and systems claimed by intelligent-design theorists to be irreducibly complex - such as the human eye, the biochemical mechanism of blood clotting, or the molecular rotary motor, called the flagellum, by which bacterial cells move - are not irreducible at all; rather, less-complex versions of the same systems have existed in the past and can be found in today's organisms.
The human eye did not appear suddenly in all its present complexity. Its formation required the integration of many genetic units, each improving the performance of preexisting, functionally less-perfect eyes. About 700 million years ago, the ancestors of today’s vertebrates already had organs sensitive to light. Mere perception of light – and, later, various levels of vision ability – were beneficial to these organisms living in environments pervaded by sunlight. Different kinds of eyes have independently evolved at least 40 times in animals, which exhibit a full range of complexities and patterns.

Because sunlight is a pervasive feature of earth’s environment, it is not surprising that organs have evolved that take advantage of it. Eyes evolved gradually and achieved very different configurations in different organisms, all serving the function of seeing. The simplest ‘organ’ of vision occurs in some single-celled organisms that have enzymes or spots sensitive to light, which helps them, for example, to move toward the surface of a pond, where they feed on the algae growing there. Some multicellular animals exhibit light-sensitive spots on their epidermis. Further steps – deposition of pigment around the spot, configuration of cells into a cup-like shape, thickening of the epidermis leading to the development of a lens, development of muscles to move the eyes and nerves to transmit optical signals to the brain – gradually led to the highly developed eyes of vertebrates and cephalopods (octopuses and squids) and to the compound eyes of insects. Natural selection favored genes and gene combinations increasing the functional efficiency of the eye. Such genetic units gradually accumulated, eventually leading to the highly complex and efficient vertebrate eye.

A record of the major stages in the evolution of the complex eye has survived in living mollusks (clams, snails, and squids). The eye of octopuses and squids is as complex as the human eye, with cornea, iris, refractive lens, retina, vitreous internal substance, optic nerve, and muscle. Limpets (Patella) have the simplest imaginable eye: just an eye spot consisting of a few pigmented cells with nerve fibers attached to them. Several intermediate stages are found in other living mollusks. One step in complexity above the limpet eye is found in slit-shell mollusks (Pleurotomaria) which have just a cup-eye, one layer of pigmented cells curved like a cup with a wide opening through which light enters, with each pigmented cell attached to a nerve fiber. More complex is the pinhole-lens eye found in Nautilus, a marine snail. The layer of pigmented cells is considerably more extensive than in slit-shell mollusks; the pigmented cells are covered towards the front with epithelium (skin) cells that are nearly closed except for a small opening (‘pinhole’) for passage of light, creating a cavity filled with water. Murex, another marine snail,
has an eye with a primitive, refractive lens covered with epithelium cells (serving as a primitive cornea); the pigmented cells extend through the back of the eye cavity (thus serving as a retina) and the nerve fibers are collected into an optic nerve that goes to the brain. The most advanced mollusk eye is found in the octopus and the squid, which is just as complex and effective as the human eye and lacks the human blind spot, an imperfection due to the fact that the nerve fibers of the human eye are collected inside the eye cavity, so that the optic nerve has to cross the retina on its way to the brain; the nerve fibers and the optic nerve of the octopus eye are outside the eye cavity and travel to the brain without crossing the retina.

The gradual process of natural selection adapting organs to functions occurs in a variety of ways, reflecting the haphazard characteristics of the evolutionary process, which are due to mutation, past history, and the vagaries of environments. In some cases the changes of an organ amount to a shift of function, as in the evolution of the forelimbs of vertebrates, which first evolved in reptiles as originally adapted for walking, but which are now used in birds for flying, in whales for swimming, and in humans for handling objects. Other cases, as the evolution of eyes, exemplify gradual advancement of the same function — seeing. In all cases, however, the process is impelled by natural selection’s favoring through time individuals exhibiting functional advantages over others of the same species.

Examples of functional shifts are many and diverse. Some transitions at first may seem unlikely because of the difficulty in identifying which possible functions may have been served during the intermediate stages. These cases are eventually resolved with further research and often by the discovery of intermediate fossil forms or living organisms with intermediate stages of development, as in the case of mollusks’ eyes. A favorite ID example of alleged irreducible complexity is the bacterial flagellum. The bacterial flagellum is, according to Michael Behe, irreducibly complex because it consists of several parts so that, if any part is missing, the flagellum will not function. It could not, therefore, says Behe, have evolved gradually, one part at a time, because the function belongs to the whole, the separate parts cannot function by themselves. But this is not so. In different species of bacteria, there are different kinds of flagella, some simpler than the one described by Behe, others just different, even very different, as in the archaea, a bacteria-like very large group of organisms. Moreover, motility in many bacteria is accomplished without flagella at all. Still more, biochemists have shown that some flagellum components may have evolved from secretory systems, which are very similar to the flagellum, but lack some of the flagellum’s components.
The bacterial flagellum is not irreducibly complex: a subset of the flagellum's complement of proteins evolved as a mechanism for bacteria to inject proteins across a cell's membrane. The argument for the irreducible complexity of the flagellum is formulated, like other ID arguments, as an 'argument from ignorance'. Because one author does not know how a complex organ may have come about, it must be the case that it is irreducibly complex. This argument from ignorance dissolves as scientific knowledge advances, or when preexisting scientific knowledge is taken into account.

_Evolution vs. Creationism_ discusses these and other issues and tells the history of the creationism/evolution controversy in Part I ('Science, Evolution, Religion, and Creationism') and Part II ('A History of the Creationism/evolution Controversy'). A useful feature of the book is Part III, 'Selections from the Literature', pp. 135-254. Texts are quoted from creationist sources, but also and mostly from scientists, philosophers, religious authorities, and legal documents, concerning different dimensions of the controversy: cosmology, biology, education, religion, the nature of science, and the courts of law. These texts are very informative and will be an excellent resource for those engaged in the controversy.

**Darwin’s Gift to Religion**

ID is bad science or not science at all. It is not supported by experiments, observations, or results published in peer-reviewed scientific journals. I further argue that ID is bad religion, bad theology, because it implies that the designer has undesirable attributes that we don’t want to predicate of God. It is not only that organisms and their parts are less than perfect, but also that deficiencies and dysfunctions are pervasive, evidencing 'incompetent' rather than 'intelligent' 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. Do the IDers want to blame God for this blunder? A human engineer would have done better.

Evolution gives a good account of this imperfection. Brain size increased over time in our ancestors; the remodeling of the skull to fit the larger brain entailed a reduction of the jaw, so that the head of the newborn would not be too large to pass through the mother's birth canal. Evolution responds to the organisms' needs through natural selection, not by optimal design but by 'tinkering', by slowly modifying existing structures. Evolution achieves 'design', as a consequence of
natural selection while promoting adaptation. Evolution’s ID is *Imperfect* Design, not Intelligent Design.

Consider also the birth canal of women, much too narrow for easy passage of the infant’s head, so that thousands upon thousands of babies and many mothers die during delivery. Surely we don’t want to blame God for this dysfunctional 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. Theologians in the past struggled with the issue of dysfunction because they thought it had to be attributed to God’s design. Science, much to the relief of theologians, provides an explanation that convincingly attributes defects, deformities, and dysfunctions to natural causes.

One more human example: why are our arms and our legs, which are used for such different functions, made of the same materials, the same bones, muscles and nerves, all arranged in the same overall pattern? Evolution makes sense of the anomaly. Our remote ancestors’ forelimbs were legs. After our hominid ancestors became bipedal and started using their forelimbs for functions other than walking, the forelimbs became gradually modified, but retaining their original composition and arrangement. Engineers start with raw materials and a design suited for a particular purpose; evolution can only modify what is already there. An engineer who would design cars and airplanes, or wings and wheels, using the same materials arranged in a similar pattern, would surely be fired.

Examples of deficiencies and dysfunctions in all sorts of organisms can be endlessly multiplied, reflecting the opportunistic, tinkerer-like character of natural selection, which achieves imperfect design 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 metaphorical 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, including between mates. 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 praying mantis 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. 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 him her spittle, which 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. Male cannibalism by their female mates is known in dozens of species, particularly spiders and scorpions. Diverse sorts of oddities associated with mating behavior, such as those I have just described, are detailed in the delightful, but accurate and documented, book by Olivia Judson, Dr. Tatiana’s Sex Advice to All Creation (2003). The world of life abounds in ‘cruel’ behaviors. Numerous predators eat their prey alive; parasites destroy their living hosts from within; in many species of spiders and insects, as noted, the females devour their mates.

In a letter to his friend, the botanist Joseph Hooker, Darwin rued: ‘What a book a Devil’s Chaplain might write on the clumsy, wasteful, blundering low & horridly cruel works of nature’. Darwin repeatedly returned to this theme, particularly in his extensive correspondence with the American biologist Asa Gray. In 1860 he wrote to Gray that ‘I cannot persuade myself that a beneficent God would have designedly created the Ichneumonidae with the express intention of their feeding within the living bodies of caterpillars, or that a cat should play with mice’.

Religious scholars in the past had struggled with imperfection, dysfunction, and cruelty in the living world, which are difficult to explain if they are the outcome of God’s design. The philosopher David Hume set the problem succinctly with brutal directness: ‘Is he [God] willing to prevent evil, but not able? Then he is impotent. Is he able, but not willing? Then he is malevolent. Is he both able and willing? Whence then evil?’ Evolution came to the rescue. Jack Haught, a contemporary Roman Catholic theologian, has written of ‘Darwin’s gift to theology’. The Protestant theologian Arthur Peacocke has referred to Darwin as the ‘disguised friend’, by quoting the earlier theologian Aubrey Moore, who in 1891 wrote that ‘Darwinism appeared, and, under the guise of a foe, did the work of a friend’. Haught and Peacocke are acknowledging the irony that the theory of evolution, which at first had seemed to remove the need for God in the world, now has convincingly removed the need to explain the world’s imperfections as outcomes of God’s design.

Indeed, a major burden was removed from the shoulders of believers, when convincing evidence was advanced that the design of organisms need not be attributed to the immediate agency of the Creator, but is
rather an outcome of natural processes. If we claim that organisms and
their parts have been specifically designed by God, we have to account
for the incompetent design of the human jaw, the narrowness of the
birth canal, and our poorly designed backbone, less than fittingly suited
for walking upright. Proponents of intelligent design would do well to
acknowledge Darwin's revolution and accept natural selection as the
process that accounts for the design of organisms, as well as for the dys-
functions, oddities, cruelties, and sadism that pervade the world of life.
Attributing these to specific agency by the Creator amounts to blasphemy.
Proponents and followers of intelligent design are surely well-meaning
people, who do not intend such blasphemy. But this is how matters
appear to a biologist.

Several excellent books have been published in recent years about
creationism, particularly intelligent design, and the presumed conflict
between evolution and religious beliefs. *Evolution vs. Creationism* is one
of the best. Eugenie C. Scott is Executive Director of the National
Center for Science Education, the leading advocacy group for the teach-
ing of evolution in the United States.