

THE STATUS OF EVOLUTION AS A SCIENTIFIC THEORY

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In the National Academy of Sciences' booklet *Science and Creationism*, we are told that the "theory of evolution has withstood the tests of science many, many times"; that "the debate [among scientists] centers only on the finer details of *how* it took place," not whether it took place; that evolution is to be classed among theories which are "supported by evidence, and which survive the rigorous testing of the scientific method," like the "germ theory of disease" and the "theory of gravity," whereas creation is to be classed among theories "that have long been invalidated by observations and experiments." (Committee on Science and Creationism, 1984, p. 6. Emphasis in original.) Similar comments occurred in the California *Science Framework Draft*:

Evolution is the central organizing theory of biology, and has fundamental importance in other sciences as well. It is no more controversial in scientific circles than gravity or electricity is...And, regardless of whether the changes in plants and animals are gradual or sporadic, the facts remain that plants and animals have evolved over time. There is no scientific dispute that evolution has occurred and continues to occur; this is why evolution is regarded as a scientific fact. (State of California, 1989, pp. 14-15.)

Is evolution fact and creation merely faith? Or is evolution faith and creation fact? Is one true and the other false, are both true or, for that matter, both false? This controversy--whether in the media, classroom or courtroom--has often generated more heat than light. Here we hope to shine a little light on one question relevant to the dispute: what is the epistemological status of evolution? How certain is it as a theory? In what sense can one say that evolution is a fact?

Some Definitions

First we should clarify some terms, for no small part of the problem relates to what is meant by such words as "evolution," "theory" and "scientific." Both sides of the controversy often use different definitions so as to capture the semantic high ground. While this may be a valuable tactic in debate and public relations, it frequently means that understanding becomes the casualty rather than one's opponents. We will here use *theory* as a generic term for a suggested explanation of observed phenomena. No attempt will be made to distinguish "theory" from such terms as "hypothesis" or "law," as was common a generation ago and as is still seen in some textbooks on science. Nor is "theory" to be understood as necessarily in contrast to

"fact." A theory may be either factual or mistaken. We *will* assume that a theory is an attempt to describe reality rather than merely a technique for reproducing observations. (For instance, we will not call locating a star in the sky by earth-centered coordinates a theory, even though this system was developed when it was thought the earth stood still and the stars crossed the sky daily.) We are thus adopting a more-or-less realist approach to science when we seek to judge whether or not a theory is actually describing reality.

The adjective *scientific* calls for a brief comment. Without getting into boundary disputes between the disciplines of science and history, or arguments among philosophers over various definitions of the scientific method, there appears to be one rather important ambiguity in the definition of "science" or "scientific." Sometimes science is understood to mean 1) an attempt to explain how things actually are. At other times, the term is used to mean 2) explanation without recourse to the supernatural. These definitions are only equivalent if in fact there has never been any supernatural intervention in the history of our universe. The claim that such alternative definitions are interchangeable is itself a distinct philosophical worldview--naturalism, secular humanism, or something of the sort. To switch back and forth between these definitions without comment has certainly tended to confuse the creation/evolution controversy, and seems to have been a significant factor in recent court decisions on the subject.

What is meant by the term *evolution*? Thomson (1982) has distinguished three meanings: 1) biological change over time; 2) descent through common ancestry; and 3) the Darwinian mechanism of mutation and natural selection. A fourth definition is also commonly used today, 4) an extension of the term beyond biology to include the origin and development of the universe, galaxy, sun and earth. Finally, the word can also be used in an everyday sense as 5) a general synonym for change or development, as in "the evolution of the computer."

We can exclude (5) from consideration, as hardly anyone but the ancient Greek philosopher Parmenides would be against evolution in this sense--certainly not creationists. At least, this is not what the present controversy is all about.

We will also exclude (4) from the scope of this particular paper. Note, however, that using the label "evolution" not only for biological origins but also for cosmological origins can easily be misleading. While it gives us the feeling that a "grand unification" has been achieved, it may lead us to overlook problems in one of these theories by encouraging us to think that evidence for one is really evidence for the other.

Two subdivisions of evolution should also be mentioned, *microevolution* and *macroevolution*. These terms cut across the first three definitions given above. Though there is some diversity in use, we will mean by "microevolution" small-scale changes in living things both within and across the lower level divisions of the biological classification scheme. "Macroevolution" would be large-scale changes such as would produce new body plans, organs or biochemical systems, whether or not these are

viewed as arising from a large number of small changes or a small number of large changes. The reason for this distinction will become more obvious as we proceed. Having singled out these three meanings of evolution, let us now consider the epistemological status of evolution under each definition.

Evolution as Biological Change

Since it is obvious that children are not identical to their parents, some biological change is as certain as the reliability of our senses. In this sense, evolution (as biological change) is a fact, at least as certain as that the earth is round.

This, however--and the equally obvious fact that individuals change as they grow older--is not really the point at issue in the creation/evolution controversy, since all creationists agree that this is so. This is at most an argument from analogy, as all agree that the mechanisms of growth and aging are different from that of Darwinism. Such considerations ought not to be brought into the debate if one is concerned to clarify what is at stake rather than muddy the waters.

More to the point is the fact that the fossil record displays increasing complexity of life as one moves up from bottom to top--no life in the lowest strata, simple life in the higher levels of the pre-Cambrian rocks, most animal phyla in the Cambrian, fish in the Ordovician strata, dinosaurs in the Triassic, a few small mammals in the Jurassic, large numbers of mammals in the Tertiary, and finally, modern mammals and humans in the Quaternary.

Creationists of the young-earth variety must deny that the geologic strata provide a sequential record of the history of life in order to avoid this conclusion. This is no doubt the reason for the popularity of flood geology in such circles. With this mechanism, young-earth creationists claim that nearly all the fossils in the geologic column were laid down at the flood and lived simultaneously on the earth up to that time. There are, however, severe scientific problems with flood geology, as old-earth creationists have regularly pointed out (e.g. Young, 1977, 1982; Wonderly, 1978, 1987).

We must admit that inferences about the past from present day observations are epistemologically of somewhat lower certainty than observations of change in oneself or ones' parents based on personal memory and photographs. Nevertheless, evolution, in sense (1), that large biological changes have taken place in geologic history, is as certain as that the earth and its geologic strata are millions to billions of years old (rather than thousands) and that the strata provide a reliable history of this time-span. Compared with other scientific theories, this would make evolution (1)--large-scale biological change--a "historical" theory like big-bang cosmology, continental drift or climatic change caused by long-term variation in the earth's orbit. This is in contrast to a "laboratory" theory like electromagnetism, the germ theory of disease, or gravity. Though we certainly don't understand everything there is to know about electromagnetism or gravity, the theories themselves refer to currently-occurring, short-term, repeatable phenomena. Such long-term actions of (say) gravity as operate

in the expansion of the universe or the formation of stars are typically considered as components of particular historical theories in cosmology or astronomy, rather than under the theory of gravity *per se*, so long as gravity itself is not viewed as changing character with time.

Evolution as Descent Through Common Ancestry

Accepting the geologic record as a history of life on earth covering more than a billion years, it is easy to see how scientists can feel that descent with modification (evolution in sense (2)) has occurred. Yet a sequence of similar fossils is not the same thing as a genealogy, and the descent of one animal from a similar one living earlier is still an inference, particularly when the difference between the two is much greater than differences between known ancestor-descendant pairs today. It might be that the apparent successor was actually independently created instead, or that it was brought to earth by extra-terrestrials. And even within the category of descent, it might be true that a successor was *created* from its predecessor by a coordinated set of mutations that could only be considered designed.

Of course, if the gradations between successive fossils are sufficiently small, such alternative suggestions will surely look like nit-picking or special pleading.

Evolutionists would then be reasonable in feeling their model was far superior to its competitors.

But in fact the gradations between successive fossils often are not small. In addition, such gaps or "missing links" do not appear to be randomly distributed through the biological classification scheme, nor are they located only at such places in the geologic column where we might assume a large amount of rock has been eroded away. Rather, as Simpson pointed out years ago:

It remains true, as every paleontologist knows, that *most* new species, genera, and families, and nearly all categories above the level of families appear in the record suddenly and are not led up to by known, gradual, completely continuous transitional sequences. (Simpson, 1953, p. 360. Emphasis in original.)

Darwin felt the force of this argument, which was raised against evolution from the first, but he hoped that such gaps would be filled-in as the fossil record was investigated. More than a century of further research, however, has not borne him out. Nor do the gaps appear to be a fluke due to the imperfection of the fossil record:

It is a fact that discontinuities are almost always and systematically present at the origin of really high categories, and, like any other systematic feature of the record, this requires explanation. (Simpson, 1953, p. 361.)

The explanation provided in the 1930s was the neo-Darwinian modification, which put nearly all evolution in small isolated populations of plants or animals that were evolving rapidly, rather than in the slow drift of large populations. This has a certain plausibility for single mutations, which might establish themselves in a small population by statistical fluctuations ($\sim N^{-1/2}$); but changes requiring several coordinated mutations need large populations to increase the chances ($\sim N$) of getting the needed additional mutations. Apart from a mechanism that predicts enormously faster transformation in smaller populations, this is purely an *ad hoc* proposal or even special pleading. We can paraphrase the argument that Sagan uses to dismiss UFO sightings: "there are no cases that are simultaneously very reliable" (a nice sequence of transitional fossils) "and very exotic (a transition between upper levels of the biological classification scheme). (Sagan, 1975, p. 199.)

Besides physical similarity, however, there is a strong biochemical resemblance among living things. The same twenty amino acids occur throughout life on earth, and the same five bases comprise all DNA molecules. Protein sequences are also similar; in general, the closer together two organisms are in the physical classification scheme, the more alike are their proteins. This certainly fits well with the proposal that living things are connected by descent from a common ancestor.

On the other hand, Denton (1986) has pointed out that the biochemical "relatedness" between various plants and animals is not what one would expect in a scheme of descent from a common ancestor. Instead, plants or animals in one large biological grouping appear to be equidistant from those in any other group, in spite of varying physical differences among themselves. For instance, the difference between the cytochrome C protein of a bacterium and any higher organism is essentially the same, whether the other organism be yeast, wheat, silk moth, tuna, pigeon or horse. Similarly, using this or other proteins, the difference between insects and vertebrates is the same, as though no one vertebrate is more closely related to invertebrates than another.

After giving numerous examples, Denton suggests that the old creationist theory of typologies (separate large categories which are not related by descent but by design) better fits the evidence here than does common descent. Neutral variation within a "type" gives rise to relatedness patterns, yet between types one observes equally distinct protein sequences.

The evolutionary alternative, that all proteins mutate at essentially constant rates, so that every living thing diverges from every other at a uniform speed, seems incredible in view of the vastly different reproduction rates of (say) bacteria and humans and the obvious evidence from the fossil record of strong physical constancy in many species (the "equilibrium" in the Punctuated Equilibria scheme) over hundreds of millions of years.

Evolution as the Darwinian Mechanism

The mechanism Darwin proposed to explain similarities and differences among the finches and turtles that he studied on the Galapagos Islands was natural selection, which operated on existing variety to favor the survival of those more fit to function and reproduce in their particular environment. The source of this variety, later named mutation, came to be identified as changes in the DNA of the organism caused by copying errors, genetic recombination or various other random disruptions. This mechanism is employed not only in Darwin's original version of evolution, but in the Neo-Darwinian revision of the 1930s and the recent Punctuated Equilibria theory. The mechanism of mutation and natural selection is generally recognized as actually functioning in the present to produce small changes in living things, such as the resistance of various insects to DDT and color variations in moths which enable them to make better use of tree bark as camouflage. It appears that evolution in sense (3) is well-established as an explanation of small-scale or microevolutionary changes. At this level, one can say that evolution (3) is a fact, or at least a "laboratory" theory describing currently-occurring, short-term, repeatable phenomena.

But evolution (3) runs into serious problems on the macroevolutionary level. Attempts to simulate the Darwinian mechanism by computer have not produced the desired result of generating new organizational structures. Instead random changes in the computer language simulating the DNA sequence have produced degradation rather than increasing order (Moorehead and Kaplan, 1967).

In addition, since transitional forms are systematically lacking in the fossil record, attempts have been made to reconstruct the pathways by which various plants and animals may have been derived from ancestors. In cases where a transition across a major subdivision of the biological classification scheme is involved, enormous problems have been encountered which raise the question whether such transitions could have occurred at all without a large number of coordinated mutations in a single generation. Denton (1986) discusses a number of such examples, including the conversion of reptile scales to flight-functional bird feathers, the formation of a flow-through lung from a dead-end lung which breathes in and out, and most astonishing, the construction of a rotary propulsion motor for bacteria! These items cannot fairly be described as the "finer details of how" evolution took place when they raise serious questions about whether evolution has taken place on the macroevolutionary level.

Comparing Evolution with other Scientific Theories

So, where does evolution stand as a scientific theory? It all depends on what is meant by evolution.

Taking evolution to mean merely *biological change*, everyone agrees that this is occurring today. The question is, how much has occurred over the history of life on earth? Those who accept the current scientific arguments for an earth several billion years old (as the authors do) see a large amount of change; those who see the earth as only a few thousand years old feel all this diversity existed at one time rather than

developing over eons. Evolution in the sense of *vast biological change* is a natural consequence of an old earth and a geologic record which accurately records the diversity of life at each period of earth's history. In sense (1) evolution is presumably only slightly less certain than an old earth and a corresponding geologic record. Taking evolution to mean *descent from a common ancestor*, everyone agrees that descendants come from ancestors and that some changes occur in the course of descent. The question is, how much of the diversity in the fossil record is a result of descent and how much a result of (say) a common designer? The apparently systematic gaps in the fossil record between the higher levels of the biological classification scheme, especially when linked with the unusual biochemical spacing between various living things, present serious evidential challenges to gradualistic forms of evolution at the macroevolutionary level, including the Punctuated Equilibria theory as usually presented. This would put evolution (in this second sense) in the class of historical theories that are currently disputed--perhaps as the volcanic vs. meteoric origin of lunar craters was disputed before the first unmanned landings occurred--but certainly not in the same category as electromagnetism, gravity and the germ theory of disease. What a majority of scientists may believe in the matter should not be the issue if we follow the guidelines laid down in the *California Science Framework Draft*:

Students should be told about evidence and how scientists reached their conclusions, not whether scientists "believe" something or how many do or don't. Scientists no more "believe" in their findings than a Superior Court Judge "believes" in a verdict (State of California, 1989).

Taking evolution to mean *the Darwinian mechanism* of mutation and natural selection, nearly everyone agrees that this occurs on the microevolutionary level. The question is, does this mechanism give evidence that it is adequate to explain the much larger diversity that we see at the upper levels of the biological classification scheme? Currently it does not, suggesting that something rather different is at work on these levels. In this sense, it appears that evolution is a historical theory without an adequate known mechanism, more like Everett's (1953) many-worlds theory of quantum mechanics⁵ or Norman's and Setterfield's (1987) theory of a changing speed of light than like continental drift or climate change due to long-term variation in the earth's orbit.

In closing, it is worth noting that proving the theory of evolution, even in most of its macroevolutionary forms, would not disprove the existence of a Creator. For the demonstration of a "naturalistic" mechanism does not, in itself, exclude a Designer who uses that mechanism as a tool to achieve certain purposes. Consequently, it is entirely possible for a scientist to investigate "how God may have done it," without compromising either his religious convictions or his scientific credibility.⁶

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Notes

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⁵See Paul Davies and J. Brown, eds. *The Ghost in the Atom: A Discussion of the Mysteries of Quantum Physics* (New York: Cambridge, 1986); Nick Herbert, *Quantum Reality* (New York: Doubleday, 1985).

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