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The "Theory of Evolution" Is a Misnomer

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The teaching of evolution in American high schools is once again under siege from creationists. The recent court challenge in *Kitzmiller et al. v. Dover Area School District,* in York County, Pennsylvania, is a case in point. Almost everyone accepts the occurrence of microevolutionary changes within species, such as selection for mutated genes that confer resistance in insects to pesticides or in bacteria to drugs used to treat disease (e.g., multidrug-resistant strains of tuberculosis have become a problem worldwide). Creationists, however, demand that biology teachers be required to introduce the "theory of intelligent design" (ID) as an alternative to the "theory of evolution" for explaining the diversity of life on Earth and the existence of millions of different species. Opponents of this view hold that ID is not a scientific theory but a religious doctrine that will violate the US Constitution if taught in public schools. Virtually all research biologists oppose the creationist view, although many of these same biologists provide creationists with a target that serves to obfuscate rather than illuminate the breadth and depth of scientific support for evolution envisioned as an unguided, self-organizing process. The target I refer to is "the theory of evolution." It invokes the notion of a single, refutable scientific theory with a veracity that hangs on the correct interpretation of the fossil record or on some other narrowly construed set of biological data.

From our current understanding of the term "scientific theory," it is anachronistic to use the phrase "theory of evolution." What constitutes a self-contained scientific theory is a subject of much philosophical hand-wringing. An acceptably succinct, although not authoritative, definition of a scientific theory is the following (online at *www.wikipedia.org* as of 2 December 2005): "In various sciences, a theory is a logically self-consistent model or framework for describing the behavior of a certain natural or social phenomenon, thus either originating from observable facts or supported by them." The theory of evolution may have fit this definition 150, or even 75, years ago, but it no longer does.

Almost 150 years ago, Darwin published his 1859 treatise on the origin of species. His ideas were seminal for our current view of evolution, but drew extensively on the work of other early 19th-century scientists, particularly the French zoologist Jean-Baptiste Lamarck. Lamarck posited that individuals modify various traits during their formative years as an adaptation to changing environmental conditions and then pass on these adaptations to their progeny. By focusing on the relative fitness of individuals, Lamarckian theory and Darwinian theory were constituted primarily at a single level of analysis—that of the individual organism. Thus, both are much closer to being "theories of evolution" than current evolutionary theory, which includes several self-contained sets of statements framed at various levels of analysis.

Current evolutionary theory underpins a scientific field of study supported by all branches of biology, from molecular genetics to ecology. Practitioners address questions regarding the lineages of molecules, genes, physiological and behavioral adaptations, individuals, extended phenotypes, and species, with a focus on how the differential survival and reproduction of individuals within interbreeding groups leads over time to the creation of biological diversity. Progress is made in this field by collecting or generating genetic, physiological, ontological, morphological, and behavioral data from living, dead, and fossilized individuals, as well as developing theories at several different levels of analysis. Among the most important applications of these theories is the use of principles such as parsimony or maximum likelihood to construct phylogenetic trees that represent our best understanding of lineage relationships among extant and extinct species.

To get a clearer understanding of why it is anachronistic to refer to all of this as the theory of evolution, I suggest we look to ecology—evolution's sibling field under the umbrella of population biology. The term "ecological theory" is used to refer to an array of theoretical frameworks providing levels of ecological analysis at the physiological, behavioral, individual, community, landscape, and regional scales of analysis, but no logically self-consistent "theory of ecology" exists. In particular, the analysis of a process at one ecological level produces only partial insight into properties emerging at some higher level. As a case in point, an analysis of how organisms forage to maximize their individual fitness has failed, despite concerted efforts, to produce a coherent theory of how the average rate of food consumption per capita at the population level is affected by competition among individuals. The lack of a unified "theory of ecology" and the existence instead of a fragmented body of "ecological theory" is evidenced by the relative use of these two terms in the scientific literature. For example, an ISI Web of Knowledge online search indicates that the phrase "ecological theory" appears 15 times more often than the "theory of ecology": a search on 5 January 2006 yielded 568 entries for the former but only 37 for the latter.

A concurrent search using the word "evolution" in place of "ecology" yielded 1366 and 578 entries, respectively: that is, the phrase "evolutionary theory" is used

only 2.4 times more frequently than "theory of evolution" in the scientific literature. Why does the phrase "theory of evolution" appear nearly 16 times as frequently as "theory of ecology" in the scientific literature covered by the ISI Web of Knowledge, while the phrases "theory of evolution" and "ecological theory" appear with almost equal frequency ? The reasons appear strongly historical. Evolution, as propounded by Lamarck and then by Darwin, was regarded as a coherent theory explaining the origins of biological diversity. Ecology, on the other hand, started out as a field of study first defined by Ernst Haeckel, in the mid-19th century, as the study of the relationship between organisms and environment, and a century later by Andrewartha and Birch (1954) as the study of the distribution and abundance of organisms.

Today certain specific theories of evolution, such as Lamarckian evolution, have been largely discredited. Others, such as intelligent design, have been debunked as unscientific (whatever the outcome of past or future court cases on the content of school biology texts). A few hold considerable credence but are diminishing in importance. The neutral theory of evolution falls into this latter category: It is used, among other things, to explain the existence of large amounts of so-called junk DNA, but some of this DNA now appears to have a biological function.

Many biologists may argue that the modern synthesis—the mid- to late-20th-century elaboration of Darwin's exposition of evolution by natural selection in terms of mutable, heritable genetic traits at the individual level—is sufficiently dominant to justify continued use of the phrase "the theory of evolution." But this dominance prevails only because we continue to put too much store in a gene-centric view of the evolutionary process, despite our increasing appreciation of the importance of the evolution of epigenetic structures (e.g., methylation patterns in DNA) and the operation of natural selection at the demic (i.e., small subpopulation) and species levels. Furthermore, the modern synthesis lies uncomfortably within the "levels of selection" debate and does not account for, among other things, overlapping genes (different genes sharing the same stretch of DNA), the emergence of the eukaryote cells from symbiotic bacterial communities, the transfer of genetic material by viral and bacterial vectors among individuals belonging to different species, or the appearance of Lamarck's ghost in the influence of the environment on DNA methylation and gene expression.

In conclusion, we population biologists should tighten up our terminology and eschew the phrase "the theory of evolution." Granted, evolution is a theoretically more cohesive field than ecology: Genes, the fundamental units of evolution, are uniquely defined in terms of their base pair coding and, hence, are exactly replicable at this structural level, whereas individuals and populations—the basic units of ecology—exhibit considerable variation with environmental influences, ensuring that even clones exhibit physiological, morphological, and behavioral differences. Unlike theories in physics, however, evolutionary theories are not based on mathematically precise laws of nature but on mathematical descriptions of idealized systems from which known complexities have been excised. Thus no unifying "theory of everything" lies just beyond the horizon of evolutionary theory. By removing "the theory of evolution" from our lexicon, we ultimately ensure that the lay public is not misled into believing evolution can be discredited by a specific group of facts that bear on only one facet of the substantial, scientifically entrenched body of knowledge that constitutes the scientific field of evolution.

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