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OVERCOMING OBSTACLES TO EVOLUTION EDUCATION

"Theory" in Theory and Practice

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Abstract A central obstacle to accepting evolution, both among students and the general public, is the idea that evolution is "just a theory," where "theory" is understood in a pejorative sense as something conjectural or speculative. Although scientists and textbooks constantly explain that the scientific use of "theory" is quite different, the pejorative use continues to cause confusion, in part because of its deep roots in a popular, Baconian, understanding of science. A constructivist approach, whereby students are helped to examine the adequacy of their preconceptions about "theory" for themselves and to revise or replace them appropriately, is recommended.

Keywords Evolution education · Theory · Fact · Francis Bacon · William Jennings Bryan · Constructivism

On February 19, 2008, the Florida state board of education voted to accept a new set of state science standards that recognize evolution as a fundamental concept underlying all of biology. That was quite a change. The previous set of state science standards sedulously avoided even using the e-word, and when the Thomas B. Fordham Foundation conducted its review of state science standards in 2005, it commented, "The superficiality of the treatment of evolutionary biology alone justifies the grade 'F'" (Gross 2005: 34). The proposed inclusion of evolution elicited a flurry of hostile comments from the public, including a handful of resolutions from county school boards insisting that evolution ought to be presented as just a theory.

However, such hostility toward evolution education in the Sunshine State is nothing new. After William Jennings Bryan retired to Florida in 1920, he lobbied for legislation prohibiting "the teaching as true of Darwinism or any other evolutionary hypothesis that links man in blood relation with any form of animal life below man" (Larson 2003: 52). Bryan was only partly successful; in 1923, the Florida legislature passed a resolution that described such teaching as "improper and subversive" but stopped short of prohibiting it altogether. Two years later, the Tennessee legislature passed a law outright banning the teaching of evolution, and the Great Commoner eventually hauled himself from Florida to Dayton, TN, for the trial of John Thomas Scopes.

Note, in Bryan's proposal, the phrase "as true." In a letter to a Florida state legislator, he explained, "A book which merely mentions [evolution] as a hypothesis can be considered as giving information as to views held, which is very different from teaching it as fact" (Larson 2003: 52). Bryan died just after the Scopes trial, but his position—that it is okay to teach about evolution but only as something conjectural or speculative, as "just a theory" and not as a fact—continues to resonate. Those creationists who were not pressing for creationism (whether in the old-fashioned form of creation science or in the new-fangled form of intelligent design) to be added to the Florida state science standards were emulating Bryan in trying to stigmatize evolution as "just a theory."

However, as the biologist T. Ryan Gregory observed in the inaugural issue of *Evolution: Education and Outreach*, "That evolution is a theory in the proper scientific sense means that there is both a fact of evolution to be explained and a well-supported mechanistic framework to account for it. To claim that evolution is 'just a theory' is to reveal both a profound ignorance of modern biological knowledge and a deep misunderstanding of the basic nature of science" (Gregory 2008: 50). Gregory was hardly the first scientist

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to emphasize the point, too: 27 years before, just as two states were enacting legislation requiring equal time for creation science, Stephen Jay Gould offered a characteristically lucid explanation of "Evolution as fact and theory" (Gould 1981).

Biology textbooks, too, are careful to explain the scientific use of the term "theory" and to emphasize the difference between the scientific and vernacular usages. *Prentice Hall Biology*, for example, makes the point in its first few pages: "Someone might say, 'Oh, that's just a theory,' to criticize an idea that is not supported by evidence. **In science, the word *theory* applies to a well-tested explanation that unifies a broad range of observations**" (Miller and Levine 2007: 13, emphasis in original). Therefore, it is clear that the problem is not just a failure to communicate. Despite the efforts of such authors, the vernacular use of "theory"—as in "evolution is just a theory"—persists and not only among creationists. What, then, is underlying the pejorative use of "theory"?

It is the philosophy of Francis Bacon, filtered through the Scottish Common Sense Realists and disseminated from Princeton University in the nineteenth century, according to the historian E. Brooks Holifield. As Baconianism was understood by American theologians in the nineteenth century, Holifield writes, "The primary object of scientific method was to gather the 'facts' through rigorous induction; the secondary aim was to formulate 'theories' that took account of the observed data. This approach assured the theologians that science would remain within severely restricted limits. The search for the 'facts' would never be complete, and 'theories' would never account for all the facts, and the observed facts served as a constant restraint and check on the theories" (Holifield 2004: 4).

Darwin's *Origin of Species* was published as scientists began to realize that the Baconian conception of science was unrealistic, vastly understating the importance of theories in the scientific enterprise. Darwin himself poked fun at the idea, writing in a letter in 1861, "at this rate a man might as well go into a gravel-pit and count the pebbles and describe the colours." But the Baconian conception was suitable for wielding against any disfavored theory, as the fundamentalist movement of the 1920s illustrates. "They insisted, with unyielding repetition, that evolutionary theory represented 'theory,' not 'facts.' With 'facts', they said, they had 'no dispute'" (Holifield 2004: 7). Likewise, on the lecture circuit, "Bryan appealed to the traditional Baconian definition of science to attack the scientific standing of Darwinism" (Larson 2003: 45).

Similarly, in Florida, just days before the state board of education was scheduled to vote on the new state science standards in 2008, there was a proposal to insert the phrase "the scientific theory of" before mentions of evolution. As the *Orlando Sentinel* reported, "By adding the word theory, which many opponents of the standards had argued for, the new version may appease those who do not view evolution as a scientific fact or those whose religious beliefs are in conflict with evolution" (Postal 2008). Clumsy, unnecessary, and apparently opposed by a majority of the writing committee, the revisions were accepted anyway, despite a valiant effort on the part of board member Roberto Martinez, who described the revisions as "an effort by people who are opposed to evolution to water down our standards" (Bhattacharjee 2008).

As the dust settled, though, it was increasingly clear that the revisions did not, after all, succeed in materially compromising the scientific integrity of the standards. Evolution was not invidiously singled out for attention: plate tectonics, cell theory, atomic theory, electromagnetism, and the Big Bang all received the same treatment. Evolution is still described, correctly, as "the organizing principle of life science" and as "supported by multiple forms of evidence" (Florida Department of Education [FDE] 2008: 55, 60). Furthermore, the standards distance themselves from the pejorative sense of "theory" that creationists from Bryan onward like to exploit: "a scientific theory is the culmination of many scientific investigations drawing together all the current evidence concerning a substantial range of phenomena; thus, a scientific theory represents the most powerful explanation scientists have to offer" (FDE 2008: 73).

However, how are teachers, in Florida and elsewhere, to help their students replace the flitch of Bacon with a conception of "theory" that is scientifically kosher? It is not enough simply to explain the distinction between the vernacular and scientific uses of the word. As Brian Alters and Sandra Alters explain, "student misconceptions… are not easily changed.… In learning evolutionary concepts in particular, students appear to need an extended exposure to and interaction with these concepts for growth in their understanding to occur" (Alters and Alters 2001: 180). In particular, they suggest teachers ought to provide situations in which students are forced to examine the adequacy of their preconceptions for themselves and to revise or replace them appropriately.

Judy Scotchmoor's "Not Just a Theory" lesson plan (Scotchmoor 2003) is a great place to start. It begins by inviting students to share their various understandings of the term, which not only helps them to articulate their preconceptions but also provides the instructor the opportunity to introduce the scientific use of the term and to distinguish it from the vernacular use. In the second part, students apply their knowledge by trying to list as many scientific theories as they can, after which the instructor displays a card with the phrase "just a theory" and asks

whether it belongs with any of the listed theories. (Thus: "Is *plate tectonics* just a theory? Is *neo-Darwinian evolutionary theory* just a theory? Is *the kinetic theory of gases* just a theory?") Students learn that "just a theory" is a useless label that ought not to be applied to *any* scientific theory, including evolution.

The Baconian conception of theory is not the only misconception of theory that students are likely to have, and "theory" is not the only term for which such a constructivist approach is necessary and desirable: consider "observation," "hypothesis," "law," "prediction," "test," and indeed "science," as well as the ways in which they interact with one another and with "theory." So, do not stop with "Not Just a Theory"! (A good source for lesson plans that integrate the topics of evolution and the nature of science is the Evolution and Nature of Science Institutes, available at http://www.indiana.edu/~ensiweb/home.html). "Even short-term classroom activities designed to confront students' misconceptions will probably not facilitate change," Alters and Alters (2001: 88–89) warn. "However, some success may occur if all science instructors in all science courses consistently used the terminology properly and constructed activities that challenged students to wrestle with the scientific versus the popular use of the word *theory*." That is advice about "theory" that deserves to be put into practice.

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