

“THEORY” AND THE PUBLIC UNDERSTANDING OF SCIENCE: REFLECTIONS ON THE EVOLUTION CONTROVERSY IN AMERICA

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ABSTRACT—Historical examination of antievolution sentiment in the United States discloses several themes, the most common of which is a lack of public understanding of the methods and goals of science. The public's failure to differentiate between “theory” and “guess” helps to explain the continued strength of antievolution sentiment and the frequent legislative attempts to eliminate or compromise the teaching of evolution in the public schools. The lack of awareness of how theories drive scientific research has been a common theme in the evolution debates from the 1860s to the present and played a major role in the Tennessee General Assembly's consideration of an anti-evolution bill in early 1996.

During the early spring of 1996, national and international media focused their attention on Tennessee. As had been the case 71 years earlier, the General Assembly was considering a bill to compromise or eliminate the teaching of evolution in the State's schools. Although the proposed bill eventually failed, the public and political support it attracted indicates the presence and power of antievolution sentiment. The continued opposition to the teaching of evolution represents a telling indictment of the American public's scientific awareness, a situation that has remained largely unchanged for more than a century.

From the beginning, Americans were exposed to evolutionary concepts in a fashion that helps to explain the ambiguous reception of the new idea. In the summer of 1860, the *American Journal of Science* published a review of Charles Darwin's *Origin of Species* by Harvard naturalist Louis Agassiz. Agassiz's impressive scientific reputation assured that his comments would be taken seriously by his colleagues. Agassiz, however, also was a public figure. Although arguably a less gifted scientist than botanist Asa Gray or physicist Joseph Henry, Agassiz captured the attention of the American public to a far greater extent than most of his contemporaries. He would retain this status among the public until his death in 1873.

Agassiz thus established an important foundation for the initial response to the concept of organic evolution by natural selection. He made it quite clear that he was singularly unimpressed with Darwin's work. He admitted that much diligence had gone into the composition of the volume, but the underlying concept of large scale developmentalism struck Agassiz as insupportable. Referring to Darwin's hypothesis as “mere guesses,” Agassiz rejected evolution through natural selection as “a scientific mistake, untrue in its facts, unscientific in its methods, and mischievous in its tendency.” The great gap in Darwin's work, according to Agassiz, was the lack of incontrovertible evidence of organic change. No evidence emerged from Darwin's study that would prove that species changed over time. “The geological record,” Agassiz stated, “even with all its imperfections exaggerated to distortion, tells now, what it has told from the beginning, that the

supposed intermediate forms between the species of different geological periods are imaginary beings, called up merely in support of a fanciful theory. The origin of all the diversity among living beings remains a mystery, as totally unexplained as if the book of Darwin had never been written; for no theory, unsupported by fact, however plausible it may appear, can be admitted in science.” (Webb, 1994:11-12)

Many of Agassiz's phrases and ideas continue to be enthusiastically applauded by those who oppose the teaching of evolution in public schools. The Tennessee legislature's recent action clearly indicates the persistence of antievolution sentiment. Equally important, however, the dismissal of Darwin's explanation as “mere theory” by those who supported the proposed legislation echoed the comments of Agassiz and several generations of antievolutionists. The public and political support for antievolution initiatives, thus, remains in large measure a product of an inaccurate view of science in general and evolution in particular. This lack of understanding of the scientific pursuit represents a common theme in the continuing evolution controversy in America.

Agassiz's skepticism concerning organic evolution never achieved the status of orthodoxy among his colleagues. A few years after Agassiz's death, noted paleontologist Othniel C. Marsh, who had discovered many important fossil remains in the American West, addressed the Nashville meeting of the American Association for the Advancement of Science. Marsh began his comments by emphasizing the critical importance of evolutionary concepts as fundamental to an understanding of life on earth. He closed his opening paragraph with a forceful statement concerning the topic: “But I am sure I need offer here no argument for evolution; since to doubt evolution to-day is to doubt science, and science is only another name for truth.” (Marsh, 1878)

Throughout the late 19th century, American intellectuals had little difficulty accepting the concept of evolution, broadly defined. Yet, beneath the surface, opposition to the new ideas remained. Although mainstream theologians largely accepted evo-

lution, the concept of natural change troubled some American religionists. Removing God from an active intervention in the organic world struck certain observers as unwarranted and dangerous. These opponents found significant support for their views in the work of Louis Agassiz, even after his death. Agassiz's sanctification of "facts" (as he defined them) provided ammunition for those who waged war against the "theory" of evolution (Moore, 1979). Consider this comment from an anti-Darwinist theologian early in the debate: "Not one decisive fact is found in the whole geologic record; no fossil relics of any species assuming new organs, or changing its internal structure . . ." Observation was central to the objections of another religious writer, who rejected fossil evidence as irrelevant and proclaimed, "We must witness the process; we must see one animal turn into another." Charles Alexander Hodge, from his position at Princeton Theological Seminary, similarly objected to the absence of "facts" in evolutionary explanations. Darwin and his followers were engaged in nothing more than speculation, in contrast to the careful accumulation of evidence that marked true science. Hodge announced in his book, *What Is Darwinism?* (1874), that "religious men believe with Agassiz that facts are sacred." The result of following a different scientific path led to erroneous conclusions which could be safely ignored. "Science, so called," the Princeton theologian wrote, "when it comes in conflict with truth, is what man is when he comes in conflict with God." (Webb, 1994:16-18)

Although the initial debates over evolution were waged within the intellectual community, they exposed a theme that would become increasingly important as the debates expanded into the public arena. The concept of "facts" as the hallmark of science took on an increasingly rigid persona that had little connection with the reality of the scientific pursuit. At least in part because of the opinions of Agassiz, Hodge, and others, the public view of scientists increasingly focused on the collection and classification of data. In this view, the scientist journeyed into the field or entered the laboratory and collected specimens or recorded measurements. These data then would be classified and, when they reached a suitable level of completeness, would reveal "truth." The scientist, from this perspective, was essentially a collector and record-keeper. That explanations were creative acts based on data was a distinction most observers missed. The concept of "theory" as such an explanation of observed phenomena was similarly unclear to most individuals outside the scientific community. These individuals continued to make no distinction between "theory" and "guess." Agassiz's dismissal of Darwinian evolution as "mere guesses" proved to be a central theme in the evolution controversy.

The controversy over the teaching of evolution in the public schools, however, has been a product of the 20th century. The expansion of public education and the inclusion of biology in the curriculum laid the foundation for the antievolution crusade. As more students attended high schools, they were exposed to biology textbooks which included discussions of evolutionary concepts. Although scientists at the turn of the century debated the details and mechanisms of evolution, they generally accepted the fundamental concept of organic change over time. The authors of the new biology texts shared this general acceptance of evolutionary concepts, but such concepts represented a potential clash with long-held views of education, religion, and science (Larson, 1985:15-27). The conflict with traditional perspectives, however, did not provide sufficient anxiety to generate a national movement to remove evolution from the public school curricu-

lum. This movement emerged following World War I and owed much of its development to William Jennings Bryan.

Seven decades later, it is easy to dismiss Bryan as a quaint symbol of America's rural past that, even in the 1920s, was on the verge of extinction. Such a dismissal would be historically inaccurate. Bryan had been one of the leading political reformers of the late 19th and early 20th centuries, arguing for such ideas as women's suffrage, the direct election of senators, a national income tax, and a foreign policy based on morality rather than military power. Indeed, it was Bryan's commitment to reform that convinced him to assume the public leadership of the anti-evolution crusade. If, as Bryan and others believed, evolution taught that all change was a product of natural forces, there existed no reason for America to concern itself with reform activity. Educators who taught evolution in the public schools, Bryan argued, trivialized reform activity and preached that evolution would take care of any changes necessary in society. When added to the growing religious movement of Protestant Fundamentalism, which tended to oppose evolution as antithetical to a literal reading of the Bible, Bryan's concern with reform provided a two-pronged attack on the suspect doctrine. Based on his belief in government activity to effect reform, the solution to the problems posed by the teaching of evolution was legislative activity to remove the topic from the curriculum (Levine, 1965). Bryan's national reputation as a political figure guaranteed that his ideas would receive significant public attention.

Despite the new foundation of antievolution thought, the debates of the 1920s continued to attack evolutionary concepts as speculative and insufficiently supported by "facts." Bryan was not the only antievolutionist making such arguments. A writer in the periodical *Christian Standard*, for example, criticized scientists for their commitment to evolution. "Making a mere theory the final test in all thinking," Glenn Gates Cole argued, "they are forced to interpret everything in its light." This practice need not be followed by opponents of evolution, as "The path of man's progress is everywhere strewn with the discarded theories of some scientist's dreaming." (Webb, 1994:62)

Yet Bryan's central role in the crusade made his comments about science especially visible and, thus, important. Making little effort to differentiate between the general concept of evolution and the possible mechanisms (such as natural selection) involved in organic change, he attacked evolution as speculation that should not be taught as anything else. In his widely circulated essay, "The Menace of Darwinism," he argued that natural selection was such a questionable concept that it required "more faith in CHANCE than a Christian is required to have in God." Later in the same essay, which also was one of his most popular speeches, he dismissed evolution by writing that "Darwinism is not science at all; it is a string of guesses strung together." In a letter to the *Chicago Evening Post* early in 1922, Bryan succinctly summarized the antievolutionist view of evolution as a scientific concept. Darwinism was nothing more than a guess, he argued, "for the word 'hypothesis' is merely a scientific synonym for guess." The evolutionary doctrine was unsupported by evidence. Scientists had been studying evolution for more than 60 years in an attempt to prove Darwinism, but they had "never found a single instance in which it can be shown that one species changed into another." Even less valid was the attempt to apply evolution to humans, as was clearly being done in the public schools of America. "Evolution, so far as it is applied to man," he told his Chicago readers, "is nothing more than a guess and ought not to be taught as if it were a fact. It ought not to be

taught even as a guess unless the teacher explains to his pupils that it is an unsupported guess. But why should a mere guess, without a fact in the universe to support it, be taught at all, when the effect of that teaching is to weaken faith in God and to undermine faith in the Bible as the Word of God?" (Webb, 1994: 68–69)

In Bryan's view, scientists and educators bore the responsibility for the intolerable situation facing America in the 1920s. By supporting and teaching evolution, they were undermining the commitment to reform that had characterized much of American life since the 1890s. Bryan had little respect for scientists. He stressed that they had played a crucial role in the carnage of World War I: Scientists had "mixed the poisonous gases and manufactured liquid fire. Intellect guided the nations, and learning without heart made war so hellish that civilization itself was about to commit suicide." Now, in the United States, scientists were in control of public education. "A scientific soviet is attempting to dictate what shall be taught in our schools," Bryan wrote in 1924, "and, in so doing, is attempting to mould the religion of the nation. It is the smallest, the most impudent, and the most tyrannical oligarchy that ever attempted to exercise arbitrary power." This power could be overcome, however, by making sure that the public gained control of education and prohibited the teaching of such dangerous doctrines as evolution. It could be done. Educators were, in Bryan's words, "hired servants." These servants should only teach what the taxpayers wanted them to teach. Legislation to outlaw the teaching of evolution was a legitimate exercise of American democracy (Webb, 1994:68–70).

The result of the antievolution crusade of the 1920s is well known, if perhaps imperfectly understood. In early 1925, the Tennessee General Assembly passed the Butler Act to outlaw the teaching of evolution in the public schools of the state. The following July, John Thomas Scopes was put on trial in Dayton for violating the law. The trial was, to be sure, an arranged event. The American Civil Liberties Union advertised in Tennessee newspapers for a teacher to serve in a test case. Dayton civic leaders embraced such a trial as a way to "boost" their community to attract new business and tourism. However, the Scopes Trial did have potential significance. Because there was virtually no doubt that Scopes would be convicted, the ACLU hoped to appeal the local decision into the federal courts for a determination of the Butler Act's constitutionality. Supporters of antievolution laws were no less interested in the outcome of the trial, as this marked the first legislation to be tested. As expected, Scopes was convicted and the appeal process began. Ironically, the Tennessee Supreme Court overturned Scopes's conviction on a technicality involving the fine imposed on the defendant, ending the appeal process in January 1927 (Larson, 1985:58–75).

The impact of the Scopes Trial transcended the case itself. Although the trial has often been described as a defeat for the fundamentalist crusade and its antievolution wing, such was clearly not the case. Admittedly, H. L. Mencken's caustic comments about the "anthropoid rabble" of rural Tennessee left a negative impression in many Americans' minds about the supporters of antievolution legislation. Supporters of such legislation, however, were encouraged by the success of their colleagues in Tennessee. An antievolution law had been passed and upheld in court. The State Supreme Court, while reversing Scopes's conviction, made clear that the statute was a legitimate one. Legislatures throughout the United States considered antievolution legislation for the remainder of the decade; such laws were passed

in Arkansas and Mississippi (Larson, 1985:75–81). Even in states without antievolution statutes, however, the place of evolution in the public school curriculum remained ambiguous. Local school boards and individual teachers tended to avoid the topic as much as possible (Webb, 1994:79–80, 95–101). Publishers minimized or deleted the discussion of evolution in their textbooks, in an effort to maintain sales. Although the crusade had evaporated by the late 1920s, the impact of the antievolution movement remained visible, as shown by the poor quality of science education in the public schools during the next 3 decades (Grabner and Miller, 1974).

The Sputnik crisis of the late 1950s heralded a change in the place of science in American public schools. Defining science and technology as crucial weapons in the nation's Cold War arsenal, the federal government committed itself to improving science education. Best symbolized by the Biological Sciences Curriculum Study materials, these efforts led to significant improvements in the teaching of science. Biology texts included clear discussions of evolution and emphasized that science was a way of knowing, rather than a memorization of data and definitions (Grobman, 1969). At the same time, the existing antievolution laws came under increased scrutiny as anachronisms in an increasingly scientific and technological world. Through legislative and court activity, all three statutes were removed by 1970 (Larson, 1985:98–124).

The re-emergence of evolution in the public school science curriculum did not please everyone. During tests of the BSCS material in the early 1960s, opposition to the new material focused on the inclusion of evolutionary concepts in the biology texts and again displayed an imperfect awareness of scientific concepts. Opponents in Phoenix, Arizona, for example, argued that evolution should not be taught in the public schools because "the theory has not been established as fact." In 1964, the Texas State Textbook Committee approved the new BSCS material but insisted that evolution be referred to as a "theory" and not as a "fact" in the new texts. Although BSCS publications were widely used in the United States during the 1960s, by the end of the decade continued opposition to the inclusion of evolution led many local school boards to replace this material with less controversial biology texts (Nelkin, 1982).

Opposition to the teaching of evolution in the public schools soon took on a different perspective with the rise of "creation-science" in the late 1960s. Led by individuals with degrees in science and engineering, this movement attempted to establish that scientific evidence existed to support a literal reading of the creation accounts in Genesis (Numbers, 1992; Toumey, 1994). In reality, however, most of the creationists' efforts were aimed toward discrediting evolutionary explanations. Transitional fossil forms such as *Archaeopteryx* were dismissed as products of evolutionists' fertile imaginations and their blind loyalty to the concept; this fossil was clearly a bird because it had wings and feathers (Gish, 1970). The use of index fossils as a relative dating device was dismissed by creationists because the concept that simpler fossils were deposited in lower strata was itself an evolutionary assumption (Morris, 1974).

Much of the creationist attack on evolution focused on what they defined as the speculative nature of the "theory." In their 1970 textbook, *Biology: A Search for Order in Complexity*, creation scientists stressed the lack of evidence to support evolution. As had been the case for more than a century, these antievolutionists embraced a concept of science that focused on the collection and classification of data. The lack of incontrovertible

observational evidence deprived evolution of a scientific foundation, according to creation-science. The idea that genetic change led to evolutionary change was similarly rejected in this text because "No one had observed mutations taking place that would change one class of animal into a *more complex* type of organism: for instance the beginning of a milk gland upon the breast of a reptile, changing it into a mammal; or a feather starting instead of a scale, changing it into a bird." (Moore and Slusher, 1970:98) A "reference handbook" published in 1974 as *Scientific Creationism* repeated many of the arguments against evolutionary speculation and provided an intriguing perspective on estimates of the age of the earth. For the most part, creation scientists accepted a relatively short age for the earth, generally on the order of 10,000 years. Such a figure was quite different from estimates based on radiometric and other dating techniques that suggested a terrestrial age of more than four billion years. The authors of *Scientific Creationism* dismissed radiometric dating as an unreliable technique because of the lack of evidence. "Not even uranium dating is capable of experimental verification," they wrote, "since no one could actually watch uranium decaying for millions of years to see what happens." (Morris, 1974:99-100, 135-137)

Although even the most superficial reading of creationist material reveals the centrality of religious and social concerns, American creationists focused their public campaigns on science. Their stated goal was to overturn the dogmatic teaching of evolution in the public schools and to replace it with "equal time" for creation-science. They made clear that they were not advocating the teaching of religious doctrine, but only the scientific evidence that would support the concept of special creation. By replacing the word "God" in their publications with the word "Creator," they apparently believed that they had avoided any objection based on the Establishment Clause of the First Amendment (Webb, 1994:186). The concept of "equal time" proved to be a seductive one to school boards, textbook commissions, and state legislatures. What could be more fair, they asked, than to present all the scientific evidence for special creation and evolution? The students could then decide which version to "believe." Such arguments attracted much public support as well, especially from citizens whose knowledge of science was restricted to consumer technologies such as televisions and microwave ovens, none of which they understood at all. If, as creation scientists argued, all accounts of the origin and development of life on earth were guesswork, why single out any specific version for favored status (Nelkin, 1982)?

The public, school board members, and legislators listened to creation scientists present their views. Careful to emphasize their own scientific credentials, creationists proved adept at convincing decision makers to embrace the equal-time concept. Scientists who testified before boards and committees against this concept were largely unprepared to counter the carefully rehearsed testimony of creationists. Faced with equally understandable presentations, legislators and others saw no real difference between the science offered by a creationist and the science offered by an evolutionist. They were obviously equally viable; both should be taught (Nelkin, 1982). At the state level, several efforts at "equal time" or "balanced treatment" laws proved successful. Although such laws were struck down by federal courts, these decisions were based on Establishment Clause considerations. In the courts' views, creation-science represented a religious view of Biblical literalism generally associated with Protestant Fundamentalism. Such preferential treatment by the State of a spe-

cific religious view violated the First Amendment (Webb, 1994: 228-251). These court decisions, however, only determined that a state body could not impose such requirements; local school boards were another matter.

Continued support for creationist ideas remained an artifact of the public's poor understanding of science. Polls conducted during the 1980s and early 1990s indicated that Americans held erroneous views concerning the most basic scientific concepts. Large numbers of respondents did not know that the earth revolved around the sun; many were unaware that an electron was smaller than an atom; others accepted the idea that dinosaurs and humans lived at the same time. The public also appeared to accept an erroneous view of how scientists pursued their craft. For most, the creative aspect of investigating nature played little role in the scientific pursuit. The mythological portrait of the scientist in the white laboratory coat recording data and finding "truth" remained the operational version of science for most Americans (Webb, 1994:254).

The State of Tennessee provides an excellent case study to summarize the recent past and current status of the modern antievolution movement. Facing a potential federal court case over the Butler Act, the General Assembly repealed the nation's most famous antievolution law in 1967. Six years later, however, Tennessee became the first state to pass an "equal time" law, usually referred to as the "Genesis Act." This law required that all discussions of evolution be described as "theory" rather than "fact." In addition, equal time was to be provided for creationist explanations. The bill was plagued with numerous constitutional flaws and was declared unconstitutional in 1975, but the concept that evolution was only one of at least two legitimate explanations of life's origin and development remained an attractive one (Larson, 1985:134-139). Over the next 2 decades, various efforts to pass "equal time" or similar legislation emerged in the General Assembly. None of these gained significant legislative support, but media coverage of these efforts kept the issue alive.

In February of 1996, Tennessee again became the focal point of antievolution sentiment and gained an embarrassing amount of negative publicity from national and international media. Bills to ban the teaching of evolution as "fact" were introduced in both houses of the legislature. The Senate bill, introduced by Tommy Burks of Monterey, quickly became the focus of the debate which raged for the next 2 months. In its initial form, the bill declared that "No teacher or administrator in a local education agency shall teach the theory of evolution except as a scientific theory" and provided for dismissal or suspension of anyone violating that policy. The details of the bill's tortuous journey through the General Assembly and its ultimate defeat in late March are well known, but one effort to amend the measure to gain additional support deserves closer attention. In mid-March, Burks rewrote his bill to differentiate between "microevolution" and "macroevolution," only the latter of which would be banned from the science classroom. Evolution within species, as Burks defined microevolution, could be taught as fact. Macroevolution, on the other hand, defined by Burks as "the unproven belief that random, undirected forces produced a world of living things," could only be taught as theory and represented the target of the pending legislation. Despite this amendment, the Senate rejected the bill on 28 March (Tennessean, 1996a).

The Burks bill, however, showed the continued misunderstanding of scientific concepts by legislators and the public they represent. In various interviews, Burks and his supporters embraced the same view of science that characterized Agassiz, Bryan, and

other opponents of evolution. The bill's sponsor told a local reporter that his efforts were actually about "truth" and not about religion. "Truth is something that is lacking all across our country," he said. "And anyone who teaches evolution as fact is not teaching the truth because it is just a theory, not a fact." Burks continued his interview by stating that, "Now, there are different notions in science, and some notions are that evolution is just a theory." Discussing the matter with an Associated Press reporter the day before his bill was defeated, Burks made his views even clearer: "If we're saying it [evolution] is a fact, we're saying you originated from a lower species. The theory of evolution is hearsay evidence." (Herald-Citizen, 1996) A letter to the editor of the Nashville *Tennessean* indicated that Burks's views enjoyed public support. Repeating charges made as early as the 1920s, this reader argued that "... evolution is merely an unproven theory with numerous gaps in its chain of logic. Therefore, belief in evolution is a religious opinion—an act of faith—just as much as creationism, and the teaching of evolution as fact is contrary to church-state separation." (Tennessean, 1996b)

The potential cost of the Burks bill also attracted significant attention late in the debate and further showed the perspective on science shared by many. Requiring the teaching of evolution as "theory" rather than "fact" would necessitate the replacement of virtually all science textbooks in the State's schools. Publishers of science texts did not include specific statements similar to Burks' perspective, nor did they include the macroevolution-microevolution distinction in Burks' amendment. When informed of this situation, Burks' refused to consider that the inclusion of evolution in science texts indicated its acceptance by the scientific community. Instead, as Burks told a Nashville reporter, "That just proves that they have been teaching evolution as fact, doesn't it?" (Tennessean, 1996c) The belief that "theory" and "guess" were synonymous and that science was only concerned with the collection and classification of data continued to underlay the opposition to teaching evolution in the public schools. As one Senate supporter of the legislation opined, in justifying his vote in favor of the Burks bill, "there was no proof that the theory of evolution was 100 per cent correct." (Chronicle, 1996)

Various other examples of public misunderstanding of the scientific pursuit, especially the meaning of the word "theory," could be cited. The scientific community, and those of us associated with it, must recognize that the public does not share our perspective on what science is and what scientists do. Our use of the word "theory," for example, is quite different from that of Jessica Fletcher, when she informs a police detective that her solution to the murder case is "just a theory." The public understanding of science has always been a goal of the scientific community, and it has consumed much of that community's time and energy. That scientists are still trying to establish organic evolution as a central part of science education, more than a century after Darwin's death, indicates how difficult the achievement of that goal remains.

All of us are educators. Whether our native habitat is the class-

room, the museum, or the laboratory, we are engaged in the pursuit and dissemination of knowledge. As educators, we have an important obligation to our students. We owe them not merely information, but the most accurate information available. Only by providing the best current knowledge can we lay the foundation for even more complete knowledge in the future. By seeking to deny us the opportunity to provide our students with this knowledge, legislation such as that introduced during the spring of 1996 erects a barrier to the advancement of learning. Educators must recognize and meet the challenge posted by such legislation. For if the challenge is not met, our students will be condemned to intellectual mediocrity and scientific illiteracy.

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