

# THE CONSTITUTIONALITY AND PEDAGOGICAL BENEFITS OF TEACHING EVOLUTION SCIENTIFICALLY

BY CASEY LUSKIN\*

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## I. INTRODUCTION

Science education and scientific progress are increasingly cited as vital to the prosperity of the United States. In his memorandum on scientific integrity, President Obama stated, "Today, more than ever before, science holds the key to our survival as a planet and our security and prosperity as a nation. It's time we once again put science at the top of our agenda and worked to restore America's place as the world leader in science and technology."<sup>1</sup> Indeed, the President's inaugural address even pledged to "restore science to its rightful place."<sup>2</sup> A less noteworthy but nonetheless highly acclaimed authority on science, "Bill Nye the Science Guy" has stated, "The future of our species probably depends on science education and our understanding of the natural world."<sup>3</sup>

Perhaps nowhere is the debate over science education more vigorous or spirited than it is over the question of how to teach evolution. As this article will discuss, an influential coalition of certain scientists, educators, textbook publishers, activists, and jurists feel that the best way to teach evolution is to only permit pro-evolution scientific viewpoints to be learned and discussed in the classroom. This contingency, collectively termed the "evolution lobby," seeks to impose nothing less than the one-sided teaching of evolution in public schools, where any scientific evidence that challenges

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1. The White House Blog, Fact Sheet on Presidential Memorandum on Scientific Integrity, [http://www.whitehouse.gov/the\\_press\\_office/Fact-Sheet-on-Presidential-Memorandum-on-Scientific-Integrity/](http://www.whitehouse.gov/the_press_office/Fact-Sheet-on-Presidential-Memorandum-on-Scientific-Integrity/) (last visited Jan. 24, 2010).

2. The White House Blog, President Barack Obama's Inaugural Address, <http://www.whitehouse.gov/blog/inaugural-address/> (last visited Jan. 24, 2010).

3. Quoted on the cover of *NOT IN OUR CLASSROOMS: WHY INTELLIGENT DESIGN IS WRONG FOR OUR SCHOOLS* (Eugenie C. Scott and Glenn Branch, eds. 2006). The book goes on to oppose teaching scientific critiques of evolution in public schools.

the prevailing consensus of neo-Darwinian evolution is effectively censored from students.

The approach of the evolution lobby is to paper over conflicts within modern neo-Darwinian evolutionary theory, and instead teach students a dumbed-down and oversimplified version of neo-Darwinism. This style of evolution-education is inaccurate and does a great disservice to students. This article will show that this stranglehold on science education is not only unnecessary, but fundamentally inimical to solving many problems faced by science education today, such as a lack of student and societal interest in, and understanding of, modern scientific knowledge. Not only is it perfectly legal to teach scientific criticisms of the prevailing scientific theory of evolution as taught in textbooks, but such scientific criticisms are grounded in credible scientific publications emanating from the mainstream scientific literature.

## II. WHAT DOES IT MEAN TO TEACH EVOLUTION SCIENTIFICALLY?

Virtually all participants in the debate over how to teach evolution are motivated by concerns that U.S. science education suffers serious deficiencies, and that the U.S. is losing its edge as the world's leader in science.<sup>4</sup> As a 2006 report from the National Research Council warned, “[p]olicy makers, scientists, and educators have expressed growing concern about the nation’s scientific literacy and the international competitiveness of its science and technology workforce.”<sup>5</sup>

### A. SCIENCE EDUCATION IN PERIL

Science education theorists today warn of two primary deficiencies in science education. First, insufficient numbers of students are being inspired to pursue careers and complete studies in science.<sup>6</sup> As the National Science Foundation (NSF) reported in 2004, there is a “troubling decline in the number of U.S. citizens who are training to become scientists and engineers.”<sup>7</sup> And second, as a 2006 report from the U.S. National Academy

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4. Michael D. Lemonick, *Are We Losing Our Edge?*, TIME, February 5, 2006, available at <http://www.time.com/time/magazine/article/0,9171,1156575,00>.

5. COMM. ON HIGH SCH. LABORATORIES: ROLE AND VISION, NAT’L RESEARCH COUNCIL, AMERICA’S LAB REPORT: INVESTIGATIONS IN HIGH SCHOOL SCIENCE 43 (2006).

6. NAT’L SCI. BD., NAT’L SCI. FOUND., THE SCIENCE AND ENGINEERING WORKFORCE: REALIZING AMERICA’S POTENTIAL 7 (2003), available at <http://www.nsf.gov/nsb/documents/2003/nsb0369/nsb0369.pdf>.

7. NAT’L SCI. BD., NAT’L SCI. FOUND., AN EMERGING AND CRITICAL PROBLEM OF THE SCIENCE AND ENGINEERING WORKFORCE: A COMPANION TO SCIENCE AND ENGINEERING INDICATORS 2004 2 (2004), available at <http://www.nsf.gov/statistics/nsb0407/nsb0407.pdf>.

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of Sciences (NAS) cautioned, most Americans are not scientifically literate:

Most people in this country lack the basic understanding of science that they need to make informed decisions about the many scientific issues affecting their lives. Neither this basic understanding—often referred to as scientific literacy—nor an appreciation for how science has shaped the society and culture is being cultivated during the high school years.<sup>8</sup>

On top of this, “results from large-scale national and international tests indicate that U.S. high school students have made little or no progress in mastery of science subject matter”<sup>9</sup> in recent years. In the view of the NSF, the inability of science education to produce a new generation of scientists and a scientifically literate population could “threaten the economic welfare and security of our country.”<sup>10</sup> Indeed, in 2001 the U.S. Commission on National Security/21<sup>st</sup> Century offered a stark warning that “[s]econd only to a weapon of mass destruction detonating in an American city, we can think of nothing more dangerous than a failure to manage properly science, technology, and education for the common good over the next quarter century.”<sup>11</sup>

#### B. SCIENTIFIC LITERACY AND INQUIRY-BASED LEARNING

In response to concerns about science education in the United States, scientific literacy is increasingly discussed among policymakers. At its base, the term implies an understanding of “the methods and processes of scientific research (scientific process) and the knowledge derived from this process (scientific content).”<sup>12</sup> Thus, scientific literacy requires not only that students learn scientific content, but also understand the methods of science—that science is “a way of knowing.”<sup>13</sup> This “scientific process” component of scientific literacy is reflected in a strong trend within science education to teach students about how scientific knowledge is generated—to wit, not just what to think, but how to think. As the American Association for the Advancement of Science (AAAS) suggests, “a science

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8. COMM. ON HIGH SCH. LABORATORIES: ROLE AND VISION, *supra* note 5, at 1.

9. *Id.* at 47.

10. NAT’L SCI. BD., *supra* note 7, at 2; *See also* COMM. ON HIGH SCH. LABORATORIES: ROLE AND VISION, *supra* note 5, at 30. (“Clearly, the United States needs high school graduates with scientific literacy—both to meet the economy’s need for skilled workers and future scientists and to develop the scientific habits of mind that can help citizens in their everyday lives.”)

11. U.S. COMM. ON NAT’L SECURITY/21ST CENTURY, ROAD MAP FOR NATIONAL SECURITY: IMPERATIVE FOR CHANGE 47 (2001), available at <http://govinfo.library.unt.edu/nssg/PhaseIIIFR.pdf>.

12. COMM. ON HIGH SCH. LABORATORIES: ROLE AND VISION, *supra* note 5, at 3.

13. AM. ASS’N FOR THE ADVANCEMENT OF SCI., UPDATE PROJECT 2061: EDUCATION FOR A CHANGING FUTURE 22 (1992); *See also*, WORKING GROUP ON TEACHING EVOLUTION, NATIONAL ACADEMY OF SCIENCES, TEACHING EVOLUTION AND THE NATURE OF SCIENCE 58 (1998).

literate person” is, in part, one who, “has a capacity for scientific ways of thinking” and “is able to use scientific knowledge and ways of thinking for personal and social purposes.”<sup>14</sup> Called the “inquiry” method of teaching students, it is a vital component of science education which recognizes that students learn best by investigating science and developing scientific critical thinking skills rather than by mere rote memorization of facts.<sup>15</sup> As the National Science Education Standards (NSES) emphasize:

Inquiry is a critical component of a science program at all grade levels and in every domain of science, and designers of curricula and programs must be sure that the approach to content, as well as the teaching and assessment strategies, reflect the acquisition of scientific understanding through inquiry.<sup>16</sup>

To ensure that teachers understand the importance of conveying the processes of science through inquiry-based science education, in 2000 the National Research Council published a guidebook for teachers titled, *Inquiry and the National Science Education Standards*. Former NAS president, Bruce Alberts, explains in the Foreword to the guidebook that “[t]eaching science through inquiry allows students to conceptualize a question and then seek possible explanations that respond to that question.”<sup>17</sup> This approach is different from many traditional methods of teaching science, which according to Alberts, “remain depressingly common today—teachers provide[] their students with sets of scientific facts and with technical words to describe those facts.”<sup>18</sup> Alberts explains that this pedagogical philosophy is detrimental to sparking student interest in science, because “if adults dismiss [students’] incessant questions as silly and uninteresting, students can lose this gift of curiosity.”<sup>19</sup> The guidebook goes on to explain how teachers should implement the inquiry method of

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14. AM. ASS’N FOR THE ADVANCEMENT OF SCI., PROJECT 2061: SCIENCE LITERACY FOR A CHANGING FUTURE, UPDATE 1994 6 (1994), available at [http://eric.ed.gov/ERIC Docs/data/ericdocs2sql/content\\_storage\\_01/0000019b/80/16/d6/c1.pdf](http://eric.ed.gov/ERIC Docs/data/ericdocs2sql/content_storage_01/0000019b/80/16/d6/c1.pdf).

15. See, NAT’L COMM. ON SCI. EDUC. STANDARDS AND ASSESSMENT, NAT’L RESEARCH COUNCIL, NATIONAL SCIENCE EDUCATION STANDARDS 56 (1996). (“The current reform effort in science education requires a substantive change in how science is taught. Implicit in this reform is an equally substantive change in professional development practices at all levels. Much current professional development involves traditional lectures to convey science content and emphasis on technical training about teaching. For example, undergraduate science courses typically communicate science as a body of facts and rules to be memorized, rather than a way of knowing about the natural world; even the science laboratories in most colleges fail to teach science as inquiry.”).

16. *Id.* at 214.

17. Bruce Alberts, *Forward* to COMM. ON THE DEV. OF AN ADDENDUM TO THE NAT’L SCI. EDUC. STANDARDS ON SCIENTIFIC INQUIRY, NAT’L RESEARCH COUNCIL, INQUIRY AND THE SCIENCE EDUCATION STANDARDS: A GUIDE FOR TEACHING AND LEARNING xii (Steve Olson & Susan Loucks-Horsley, eds. 2000).

18. *Id.*

19. *Id.*

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teaching science:

Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. *Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations.*<sup>20</sup>

The guidebook further suggests that students learn how to “formulate and revise scientific explanations and models using logic and evidence” and “recognize and analyze alternative explanations and models.”<sup>21</sup>

As would be expected, such values are interwoven throughout the NSES, which recommends that students engage in “identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations.”<sup>22</sup> More specifically, the standards suggest that students use scientific inquiry to develop “the critical abilities of analyzing an argument by reviewing current scientific understanding, weighing the evidence, and examining the logic so as to decide which explanations and models are best.”<sup>23</sup> The NSES also recognizes the importance of studying the “strengths and weaknesses” of scientific claims:

At each of the steps involved in inquiry, students and teachers ought to ask[:] “[W]hat counts?” What data do we keep? What data do we discard? What patterns exist in the data? Are these patterns appropriate for this inquiry? What explanations account for the patterns? Is one explanation better than another?

In justifying their decisions, students ought to draw on evidence and analytical tools to derive a scientific claim. In turn, students should be able to assess both the strengths and weaknesses of their claims.<sup>24</sup>

The NSES similarly stresses that “[t]hroughout the process of inquiry” students should “constantly evaluate and reevaluate the nature and strength of evidence and share and then critique their explanations and those of

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20. COMM. ON THE DEV. OF AN ADDENDUM TO THE NAT’L SCI. EDUC. STANDARDS ON SCIENTIFIC INQUIRY, NAT’L RESEARCH COUNCIL, INQUIRY AND THE SCIENCE EDUCATION STANDARDS: A GUIDE FOR TEACHING AND LEARNING 13-14 (*quoting* NAT’L COMM. ON SCI. EDUC. STANDARDS AND ASSESSMENT, *supra* note 15, at 23) (emphasis added).

21. *Id.* at 19.

22. NAT’L COMM. ON SCI. EDUC. STANDARDS AND ASSESSMENT, *supra* note 15, at 23.

23. *Id.* at 175.

24. COMM. ON THE DEV. OF AN ADDENDUM TO THE NAT’L SCI. EDUC. STANDARDS ON SCIENTIFIC INQUIRY, *supra* note 20, at 18–19.

others.”<sup>25</sup>

Other science education authorities concur with the NSES. In 2001, the National Science Teachers Association (NSTA) and AAAS co-published the *Atlas of Scientific Literacy*, which emphasizes that students should “[i]nsist that the critical assumptions behind any line of reasoning be made explicit so that the validity of the position being taken—whether one’s own or that of others—can be judged.”<sup>26</sup> The *Atlas* further suggests that students “[n]otice and criticize the reasoning in arguments in which fact and opinion are intermingled or the conclusions do not logically follow from the evidence given.”<sup>27</sup> The *Atlas* is intended to implement the AAAS’s *Benchmarks for Scientific Literacy*, produced by its Project 2061, an ambitious program aiming to dramatically improve American science education by the next return of Halley’s Comet in the year 2061. The *Benchmarks* also contain strong proscriptions for implementing the inquiry method when teaching science, such as found in its section on “Habits of Mind:”

View science and technology thoughtfully, being neither categorically antagonistic nor uncritically positive.<sup>28</sup>

Know why curiosity, honesty, openness, and skepticism are so highly regarded in science and how they are incorporated into the way science is carried out; exhibit those traits in their own lives and value them in others.<sup>29</sup>

Likewise, in 2009 the College Board, which issues the SAT exam and Advanced Placement course curricula, released recommended science education standards which strongly emphasize the importance of inquiry-based science learning:

In the course of learning to construct testable explanations and predictions, students will have opportunities to identify assumptions, to use critical thinking, to engage in problem solving, to determine what constitutes evidence, and to consider alternative explanations of observations.<sup>30</sup>

The standards go on to recommend that “[b]oth the evidence that supports the claim and the evidence that refutes the claim should be accounted for in the explanation. Alternative explanations should also be

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25. *Id.* at 124.

26. AM. ASS’N FOR THE ADVANCEMENT OF SCI., *ATLAS OF SCIENTIFIC LITERACY* 17 (2001).

27. *Id.*

28. AM. ASS’N FOR THE ADVANCEMENT OF SCI., *BENCHMARKS FOR SCIENCE LITERACY, PROJECT 2061* 287 (1993).

29. *Id.*

30. THE COLL. BD., *SCIENCE: COLLEGE BOARD STANDARDS FOR COLLEGE SUCCESS* 5 (2009), available at <http://professionals.collegeboard.com/profdownload/cbscs-science-standards-2009.pdf>.

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taken into consideration.”<sup>31</sup> Likewise, “The reasoning that supports an explanation . . . should allude to supporting evidence and counterevidence, include an interpretation of data as it relates to the claim, and consider multiple alternative explanations.”<sup>32</sup> Teachers and students should understand that “scientific discourse” requires students to justify “not just *what* they know, but *how* they know it—claims are made; evidence is produced; and explanations are formulated, revised and extended through science discourse during which claims, evidence and reasoning are discussed and critiqued.”<sup>33</sup> In this regard, “students should also be able to recognize and refute claims that do not reflect the use of scientific evidence and reasoning.”<sup>34</sup> The College Board thus recommends that “[c]riteria for the evaluation of a scientific explanation include”<sup>35</sup> the following tenets:

- Integration of fact and opinion is avoided.
- Making conclusions that do not follow logically from the evidence is avoided.
- Explanation includes an explicit statement about the critical assumptions of the explanation.
- The claim is appropriately aligned to the scientific question or the prediction it is intended to address.
- The quality and quantity of the evidence used to support the explanation is appropriate.
- All of the evidence is used, not just selected portions of the evidence.
- The reasoning linking the claim to the evidence is strong. The reasoning is considered strong if it includes well-established, accurate scientific principles and if the steps of reasoning form a logical progression.<sup>36</sup>

Mirroring the NSES, the College Board’s definition of “scientific investigation” agrees that “[s]cientific investigations require identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations.”<sup>37</sup>

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31. *Id.* at 14.

32. *Id.*

33. *Id.* at 7.

34. *Id.* at 14.

35. *Id.* at 15.

36. THE COLL. BD., SCIENCE: COLLEGE BOARD STANDARDS FOR COLLEGE SUCCESS at 15.

37. *Id.* at 207.

C. THE IMPORTANCE OF SKEPTICISM, TENTATIVENESS, DEBATE, AND  
DISAGREEMENT WITHIN SCIENCE

One oft-cited source among science education authorities is a book co-published by the AAAS titled *Science for All Americans*, which “defines science literacy and lays out some principles for effective learning and teaching.”<sup>38</sup> The book is intended to encapsulate the goals of Project 2061, and explains why citizens require an understanding of the scientific process to function in society:

Scientific habits of mind can help people in every walk of life to deal sensibly with problems that often involve evidence, quantitative considerations, logical arguments, and uncertainty; without the ability to think critically and independently, citizens are easy prey to dogmatists, flimflam artists, and purveyors of simple solutions to complex problems.<sup>39</sup>

*Science for All Americans* emphasizes—and historian of science David C. Lindberg agrees—that students need to understand that a scientist’s “beliefs are tentative, not dogmatic.”<sup>40</sup> *Science for All Americans* stresses the importance of inculcating scientific values of skepticism and open-mindedness into students through science education:

Science education is in a particularly strong position to foster three of these attitudes and values—curiosity, openness to new ideas, and skepticism.

....

... People with closed minds miss the joy of discovery and the satisfaction of intellectual growth throughout life. Because, as this report makes clear, the purpose of science education is not exclusively to produce scientists, it should help all students understand the great importance of carefully considering ideas that at first may seem disquieting to them or at odds with what they generally believe. The competition among ideas is a major source of tensions within science, between science and society, and within society. Science education should document the nature of such tensions from the history of science—and it should help students see the value to themselves and society of participating in the push and pull of conflicting ideas.

Science is characterized as much by skepticism as by

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38. American Association for the Advancement of Science, *Science For All Americans*, <http://www.project2061.org/publications/sfaa/default.htm> (last visited Dec. 18, 2009).

39. F. JAMES RUTHERFORD & ANDREW AHLGREN, AM. ASS'N FOR THE ADVANCEMENT OF SCI., *SCIENCE FOR ALL AMERICANS* vi (1st prt. 1990). See also, COMM. ON HIGH SCH. LABORATORIES: ROLE AND VISION, *supra* note 5, at 28.

40. DAVID C. LINDBERG, *THE BEGINNINGS OF WESTERN SCIENCE* 2 (1<sup>st</sup> ed. 1992).

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openness . . . . Science education can help students to see the social value of systematic skepticism and to develop a healthy balance in their own minds between openness and skepticism.<sup>41</sup>

Ernst Mayr similarly writes in the NAS's *Teaching Evolution and the Nature of Science* that "[a]nother feature of science that distinguishes [it] from theology is its openness" and "[o]ne of the most characteristic features of science is this openness to challenge."<sup>42</sup> In fact Mayr emphasizes that "[t]he willingness to abandon a currently accepted belief when a new, better one is proposed is an important demarcation between science and religious dogma."<sup>43</sup> Dan Wivagg, former associate editor of the journal *American Biology Teacher*, likewise explains the importance of skepticism in science:

Skepticism is the essence of science. A good biologist is continually questioning what he or she 'knows' and examining skeptically the results of other biologists' research. It is therefore important for us to teach our biology students to become skeptical of what they read and hear. They will then understand the process of science and have an appreciation for the dynamic nature of biological 'facts.'<sup>44</sup>

Thus, as the NAS acknowledges, scientific knowledge is tentative, for "[t]ruth in science . . . is never final, and what is accepted as a fact today may be modified or even discarded tomorrow."<sup>45</sup> In the words of Lindberg, "Bertrand Russell has argued that 'it is not *what* the man of science believes that distinguishes him, but *how* and *why* he believes it. His beliefs are tentative, not dogmatic; they are based on evidence, not on authority or intuition.'<sup>46</sup>

According to the AAAS's *Science for All Americans*, the result of such pedagogical emphases is that: "Education should prepare people to read or listen to such assertions critically, deciding what evidence to pay attention to and what to dismiss, and distinguishing careful arguments from shoddy ones."<sup>47</sup>

These educational authorities hold that science cannot progress when views are held dogmatically and are not subject to future discoveries. In this

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41. RUTHERFORD, *supra* note 39, at 173–74.

42. ERNST MAYR, *THE CONCERNS OF SCIENCE* an excerpt from *THIS IS BIOLOGY: THE SCIENCE OF THE LIVING WORLD* (First Harvard University Press 1997) *reprinted in* WORKING GROUP ON TEACHING EVOLUTION, NAT'L ACAD. OF SCIS., *TEACHING ABOUT EVOLUTION AND THE NATURE OF SCIENCE* 43 (1998).

43. *Id.*

44. Dan Wivagg, *Lies, Skepticism and Science*, 50:2 *THE AMERICAN BIOLOGY TEACHER* 74 (1988).

45. STEERING COMM. ON SCI. AND CREATIONISM, NAT'L ACAD. OF SCIS., *SCIENCE AND CREATIONISM: A VIEW FROM THE NATIONAL ACADEMY OF SCIENCES* 2 (2<sup>nd</sup> ed. 1999).

46. LINDBERG, *supra* note 40, at 1–2 (internal citations omitted).

47. RUTHERFORD, *supra* note 39, at 182.

regard, courts have agreed with science educators that science is more than just a body of knowledge, but also a process of obtaining knowledge that often entails debate, critique, and disagreement. In *Daubert v. Merrell Dow Pharmaceuticals*, the Supreme Court rejected the “general acceptance” test for admitting scientific evidence, and explained that under the Federal Rules of Evidence, “scientific knowledge” must be grounded in the methods of science:

The adjective “scientific” implies a grounding in the methods and procedures of science . . . . [I]n order to qualify as “scientific knowledge,” an inference or assertion *must be derived by the scientific method*.<sup>48</sup>

In a brief submitted to the Court in *Daubert*, the AAAS and the NAS likewise observed that “[s]cience is not an encyclopedic body of knowledge about the universe. Instead, it represents a *process* for proposing and refining theoretical explanations about the world that are subject to further testing and refinement.”<sup>49</sup> Similarly, *Science for All Americans* argues that “[s]cience is more than a body of knowledge and a way of accumulating and validating that knowledge” but is also “a social activity that incorporates certain human values.”<sup>50</sup> These values include “skepticism and a distaste for dogmatism” which are “highly characteristic of the scientific endeavor.”<sup>51</sup> Indeed, the AAAS authors state that “[s]cience, mathematics, and engineering prosper because of the institutionalized skepticism of their practitioners.”<sup>52</sup> The authors thus offer proscriptions for inculcating these values in students:

In science classrooms, it should be the normal practice for teachers to raise such questions as: How do we know? What is the evidence? What is the argument that interprets the evidence? Are there alternative explanations or other ways of solving the problem that could be better? The aim should be to get students into the habit of posing such questions and framing answers.

Students should experience science as a process for extending understanding, not as unalterable truth. This means that teachers take care not to convey the impression that they themselves or the textbooks are absolute authorities whose conclusions are always correct. By dealing with the credibility of scientific claims, the

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48. *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579, 590 (1993) (emphasis added).

49. Brief for the American Association for the Advancement of Science and the National Academy of Sciences as Amici Curiae Supporting Respondent, *Daubert v. Merrill Dow Pharmaceuticals, Inc.*, at 7, 509 U.S. 579 (1993) (No. 92–102).

50. RUTHERFORD, *supra* note 39, at 190.

51. *Id.*

52. *Id.* at 191.

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overturn of accepted scientific beliefs, and what to make out of disagreement among scientists, science teachers can help students to balance the necessity for accepting a great deal of science on faith against the importance of keeping an open mind.<sup>53</sup>

*Science for All Americans* observes that, “[s]cientists may often disagree about the value of a particular piece of evidence or about the appropriateness of particular assumptions that are made—and therefore disagree about what conclusions are justified.”<sup>54</sup> Indeed, scientists often vigorously disagree with new ideas:

In the short run, new ideas that do not mesh well with mainstream ideas may encounter vigorous criticism, and scientists investigating such ideas may have difficulty obtaining support for their research. Indeed, challenges to new ideas are the legitimate business of science in building valid knowledge. Even the most prestigious scientists have occasionally refused to accept new theories despite there being enough accumulated evidence to convince others.<sup>55</sup>

Such explanations of the scientific process corroborate the theories of Thomas Kuhn, the influential sociologist of science who contended that “[n]o part of the aim of normal science is to call forth new sorts of phenomena; indeed those that will not fit the box are often not seen at all. Nor do scientists normally aim to invent new theories, and they are often intolerant of those invented by others.”<sup>56</sup> Kuhn even notes that defenders of scientific orthodoxy “will devise numerous articulations and *ad hoc* modifications of their theory in order to eliminate any apparent conflict [with data that contradicts the hypothesis].”<sup>57</sup>

This attitude, however, can be dangerous to the progress of science when it prevents scientists from considering new ideas. *New York Times* science writer Nicholas Wade warns of the dangers when scientific dissent is stifled:

Conformity and group-think are attitudes of particular danger in science, an endeavor that is inherently revolutionary because progress often depends on overturning established wisdom . . . .

. . . [A]cademic monocultures . . . are the kind of thing that sabotages scientific creativity . . . .

. . . .

What’s wrong with consensus is not the establishment of a

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53. *Id.*

54. *Id.* at 6.

55. *Id.* at 8–9.

56. THOMAS S. KUHN, *THE STRUCTURE OF SCIENTIFIC REVOLUTIONS* 24 (2<sup>nd</sup> ed. 1970).

57. *Id.* at 78.

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majority view, which is necessary and legitimate, but the silencing of skeptics.<sup>58</sup>

Wade further observes that scientists are often pressured to conform and not speak out against the prevailing view:

The strength of this urge to conform can silence even those who have good reason to think the majority is wrong. You're an expert because all your peers recognize you as such. But if you start to get too far out of line with what your peers believe, they will look at you askance and start to withdraw the informal title of "expert" they have implicitly bestowed on you. Then you'll bear the less comfortable label of "maverick," which is only a few stops short of "scapegoat" or "pariah."<sup>59</sup>

While many would like to believe that scientists always follow the evidence where it leads, Stephen Jay Gould cautions that scientists' "ways of learning about the world are strongly influenced by the social preconceptions and biased modes of thinking that each scientist must apply to any problem. The stereotype of a fully rational and objective 'scientific method,' with individual scientists as logical and interchangeable robots, is self-serving mythology."<sup>60</sup> The importance of allowing dissent—even unpopular dissent—within the scientific community was made emphatically and eloquently by Gould writing with other scientists in an amicus brief to the Supreme Court in *Daubert*:

Judgments based on scientific evidence, whether made in a laboratory or a courtroom, are undermined by a categorical refusal even to consider research or views that contradict someone's notion of the prevailing "consensus" of scientific opinion. Science progresses as much or more by the replacement of old views as by the gradual accumulation of incremental knowledge. Automatically rejecting dissenting views that challenge the conventional wisdom is a dangerous fallacy, for almost every generally accepted view was once deemed eccentric or heretical. Perpetuating the reign of a supposed scientific orthodoxy in this way, whether in a research laboratory or in a courtroom, is profoundly inimical to the search for truth. . . .

. . . .

. . . The quality of a scientific approach or opinion depends on the strength of its factual premises and on the depth and consistency

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58. Nicholas Wade, *Researcher Condemns Conformity Among His Peers*, NEW YORK TIMES BLOG ( July 23, 2009), <http://tierneylab.blogs.nytimes.com/2009/07/23/researcher-condemns-conformity-among-his-peers/>.

59. *Id.*

60. Stephen Jay Gould, *In the Mind of the Beholder*, 103:2 NATURAL HISTORY, Feb. 1994 at 15.

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of its reasoning, not on its appearance in a particular journal or on its popularity among other scientists.<sup>61</sup>

Unfortunately, some scientific researchers have reported that the mainstream scientific community is closed off to viewpoints that dissent from prevailing theories of evolution. As biologist Günter Theißen wrote in the journal *Theory in Biosciences*:

It is dangerous to raise attention to the fact that there is no satisfying explanation for macroevolution. One easily becomes a target of orthodox evolutionary biology and a false friend of proponents of non-scientific concepts.<sup>62</sup>

Similarly, Oregon State University zoologist John Ruben reports that his dissent from the predominant view that birds evolved from dinosaurs has fallen prey to “museum politics”:

But old theories die hard, Ruben said, especially when it comes to some of the most distinctive and romanticized animal species in world history.

“Frankly, there’s a lot of museum politics involved in this, a lot of careers committed to a particular point of view even if new scientific evidence raises questions,” Ruben said. In some museum displays, he said, the birds-descended-from-dinosaurs evolutionary theory has been portrayed as a largely accepted fact, with an asterisk pointing out in small type that “some scientists disagree.”

“Our work at OSU used to be pretty much the only asterisk they were talking about,” Ruben said. “But now there are more asterisks all the time. That’s part of the process of science.”<sup>63</sup>

Indeed, there are many other well-documented examples of scientists and academics that have faced intolerance and persecution due to their scientific skepticism of neo-Darwinian evolution.<sup>64</sup> This trend is dangerous to the progress of science, making it all the more important to educate students about the importance of open-mindedness, skepticism, and rigorous scientific debate to the scientific method.

#### D. INQUIRY, AND FAUX-INQUIRY BASED APPROACHES TO TEACHING EVOLUTION

The many authorities cited above suggest that in addition to teaching

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61. Brief Amici Curiae of Phys., Scientists, & Historians of Sci. in Support of Petitioners, *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, at 2–6, 509 U.S. 579 (1993) (No. 92–102).

62. Günter Theißen, *The Proper Place of Hopeful Monsters in Evolutionary Biology*, 124 *THEORY IN BIOSCIENCES* 349–69 (2006).

63. ScienceDaily.com, Science News, Discovery Raises New Doubts About Dinosaur-bird Links (June 9, 2009), <http://www.sciencedaily.com/releases/2009/06/090609092055.htm>.

64. See JONATHAN WELLS, *THE POLITICALLY INCORRECT GUIDE TO DARWINISM AND INTELLIGENT DESIGN* (2006).

scientific content, science education ought to, at the very least, instill the following in students:

- An understanding of the methods used by science;
- The ability to practice the habits of mind employed by scientists;
- Critical and logical thinking skills;
- The ability to identify assumptions, evaluate arguments, and consider counter-arguments and alternative explanations;
- An understanding of the ways that scientists challenge scientific hypotheses;
- An appreciation for the tentative nature of scientific knowledge;
- A willingness to keep an open mind;
- A skeptical mindset that can evaluate and reject false claims; and
- A distaste for dogmatism.

With such a weight of authorities recommending inquiry-based science education, one would expect that evolution would be routinely taught using the inquiry method—to wit, it would be *taught scientifically*. Policies that advocate teaching evolution scientifically (TES) would thereby require that students apply inquiry-based learning when studying evolution. Such an approach would encourage students to:

- Learn more about the science pertaining to evolution;
- Approach evolution skeptically, with an open mind about the accuracy or falsity of neo-Darwinian evolution;
- Avoid a dogmatic mindset, one way or the other, when investigating evolution;
- Logically and critically evaluate the evidence regarding evolution;
- Identify assumptions inherent in the arguments for evolution;
- Understand the ways that scientists support or challenge evolution;
- Learn about scientific disagreement about prevailing theories of evolution; and
- Consider alternative hypotheses to prevailing neo-Darwinian explanations of evolution.

Regrettably, many opponents of TES policies appear to not want students to seriously engage in such inquiry-based reasoning when studying evolution.

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Thus, there is no small measure of hypocrisy that most of the science education authorities cited above laud the importance of inquiry-based science education—with all of its critical thinking, skepticism, and consideration of alternative explanations—but then effectively jettison such pedagogical philosophies when recommending methods of teaching evolution. As the NAS boldly declared in a 2008 booklet *Science, Evolution, and Creationism*, “[t]here is no scientific controversy about the basic facts of evolution,” and evolution is “so well established that no new evidence is likely to alter [it].”<sup>65</sup> They even assert “there are no viable alternatives to evolution in the scientific literature” and “scientists no longer question whether biological evolution has occurred.”<sup>66</sup> Such a perspective does not instill in students the scientific values of skepticism or open-mindedness, but instead instills in students an attitude inimical to the scientific method: dogmatism. Moreover, such pedagogical philosophies do not allow students to learn about evolution by critically investigating the evidence.

As would be expected, various educational authorities recommend one-sided and dogmatic standards for students studying evolution. In its recommended standards for learning about evolution, the College Board suggests that students learn about evidence *for* evolution, but make no proscriptions for learning about scientific challenges to evolution:

The fossil record, particularly in invertebrates, provides evidence of biological evolution.<sup>67</sup>

Provide evidence—reported in print and electronic resources, and regarding similarities and differences between organisms from the fossil record and preserved DNA—that supports the idea of descent with modification. Explain how similarities and differences among organisms support the idea of descent with modification.<sup>68</sup>

Charles Darwin’s theory of evolution had a dramatic effect on biology because of his use of clear and understandable argument and the inclusion of a massive array of evidence to support the argument.<sup>69</sup>

Likewise, the AAAS’s *Benchmarks for Scientific Literacy* expect students to see neo-Darwinism as a fully adequate scientific explanation, but make no requirements that students learn about scientific challenges to evolution:

By the end of the 12<sup>th</sup> grade, students should know that . . . [t]he theory of natural selection provides a scientific explanation or the

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65. NAT’L ACAD. OF SCIS. & INST. OF MED., *SCIENCE, EVOLUTION, AND CREATIONISM* 11, 52 (2008).

66. *Id.* at 11, 42.

67. THE COLL. BD., *supra* note 30, at 39.

68. *Id.* at 53.

69. *Id.* at 55.

history of life on earth as depicted in the fossil record and in the similarities evident within the diversity of existing organisms.<sup>70</sup>

By the end of the 12<sup>th</sup> grade, students should know that . . . [m]olecular evidence substantiates the anatomical evidence for evolution and provides additional detail about the sequence in which various lines of descent branched off from one another.<sup>71</sup>

Similarly, the NSES offers recommended science standards that essentially require students to assent to the view that evolution is supported by the evidence, without any suggested opportunities for students to study scientific dissent from neo-Darwinism:

The great diversity of organisms is the result of more than 3.5 billion years of evolution that has filled every available niche with life forms.<sup>72</sup>

Natural selection and its evolutionary consequences provide a scientific explanation for the fossil record of ancient life forms, as well as for the striking molecular similarities observed among the diverse species of living organisms.<sup>73</sup>

While it is both necessary and appropriate to teach students about the scientific evidence supporting evolution, such standards encourage students to treat evolution like dogma. They discourage students from questioning modern evolutionary biology, such as common descent or the sufficiency of natural selection to account for the adaptive complexity of life. Instead, they inculcate a tolerance for dogmatism and discourage students from asking fundamental questions about the sufficiency of modern evolutionary thinking.

Unsurprisingly, such modes of teaching evolution have become incorporated into state science standards. In 2008, Florida adopted science standards that followed the proscriptions of the NAS, namely, requiring students to learn evolution in an ardently pro-Darwin-only fashion:

- A. The scientific theory of evolution is the fundamental concept underlying all of biology.
- B. The scientific theory of evolution is supported by multiple forms of scientific evidence.
- C. Organisms are classified based on their evolutionary history.
- D. Natural selection is a primary mechanism leading to evolutionary change.<sup>74</sup>

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70. AM. ASS'N FOR THE ADVANCEMENT OF SCI., *supra* note 28, at 121, 125.

71. *Id.*

72. NAT'L COMM. ON SCI. EDUC. STANDARDS AND ASSESSMENT, *supra* note 15, at 185.

73. *Id.*

74. STATE BD. OF EDUC., FLORIDA'S STUDENT PERFORMANCE SCIENCE STANDARDS 89 (2008), available at <http://www.fdoestem.org/Uploads/1/docs/Science%20Standards%20Both->

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While there is nothing wrong with students learning about the scientific evidence supporting evolution or the importance that many scientists place on evolutionary biology, students were given no opportunity to investigate scientific dissent from Darwinism. Instead, various benchmarks have been adopted that essentially require uncritical assent to evolution by the student. Some of these standards were clearly modeled after the above, including:

Recognize that fossil evidence is consistent with the scientific theory of evolution that living things evolved from earlier species.<sup>75</sup>

Explore the scientific theory of evolution by recognizing and explaining ways in which genetic variation and environmental factors contribute to evolution by natural selection and diversity of organisms.<sup>76</sup>

Explain how the scientific theory of evolution is supported by the fossil record, comparative anatomy, comparative embryology, biogeography, molecular biology, and observed evolutionary change.<sup>77</sup>

Identify basic trends in hominid evolution from early ancestors six million years ago to modern humans, including brain size, jaw size, language, and manufacture of tools.<sup>78</sup>

Recognize that there are scientific explanations of how life began.<sup>79</sup>

Such standards are not intended to inculcate scientific values such as skepticism, openness to challenge, or consideration of alternative explanations. Bluntly stated, the goal of such standards is to guide students into accepting evolution, not to foster critical thinking or to encourage them to truly explore whether the scientific evidence supports, or does not support, neo-Darwinian evolution.

Dogmatic evolution standards are found in other state science guidelines, but only a couple more examples will suffice. California's science standards require that "[s]tudents know how independent lines of evidence from geology, fossils, and comparative anatomy provide the bases for the theory of evolution,"<sup>80</sup> without asking students to consider any evidence that does not support the theory of evolution. The New York State Science Standards call evolution "the central unifying theme of biology" and state it is "well documented by extensive evidence from a wide variety

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75. *Id.* at 60; *See* SC.7.L. 15.1.

76. *Id.*; *See* SC.7.L. 15.2

77. *Id.* at 89; *See* SC.912.L. 15.1.

78. *Id.*; *See* SC.912.L. 15.10.

79. *Id.* at 90; *See* SC.912.L. 15.Su.c.

80. CALIFORNIA DEP'T OF EDUC., SCIENCE CONTENT STANDARDS FOR CALIFORNIA PUBLIC SCHOOLS 23 (2003), available at <http://www.cde.ca.gov/BE/ST/SS/documents/sciencstnd.pdf>.

of sources.”<sup>81</sup> The standards teach, without question, that “Natural selection and its evolutionary consequences provide a scientific explanation for the fossil record of ancient life-forms, as well as for the molecular and structural similarities observed among the diverse species of living organisms” and that “The diversity of life on Earth today is the result of natural selection.”<sup>82</sup> The standards even uncritically assert that “Behaviors have evolved through natural selection. The broad patterns of behavior exhibited by organisms are those that have resulted in greater reproductive success.”<sup>83</sup> Likewise, New Jersey requires students to learn that “[a]natomical evidence supports evolution and provides additional detail about the sequence of branching of various lines of descent” and that “[m]olecular evidence (e.g., DNA, protein structures, etc.) substantiates the anatomical evidence for evolution and provides additional detail about the sequence in which various lines of descent branched.”<sup>84</sup> No requirement is made for students to learn about scientific evidence that challenges these viewpoints.

New Jersey’s standards further require students to understand that “[t]he principles of evolution (including natural selection and common descent) provide a scientific explanation for the history of life on Earth as evidenced in the fossil record and in the similarities that exist within the diversity of existing organisms.”<sup>85</sup> While there should be no objections to learning about natural selection, such standards make no provision for students to learn about the many scientific viewpoints that question the adequacy of natural selection to explain the diversity of life.

Textbook publishers write textbooks which meet the science standards adopted by state educational authorities. Large states, such as California or Florida, are especially influential upon textbook content because publishers find it most economical to tailor their textbooks to satisfy the demands and requirements of the larger textbook markets. Since dogmatism in evolution-education is required by these states, one-sided evolution education finds its way into textbooks nationwide.

For example, Campbell, Reece, and Mitchell’s textbook *Biology: Concepts and Connections*, forces students to engage in critical thinking exercises aimed at encouraging uncritical support for evolution, such as: “Write a paragraph briefly describing the evidence for evolution.”<sup>86</sup>

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81. THE UNIV. OF THE STATE OF N. Y., THE STATE EDUC. DEP’T, THE LIVING ENVIRONMENT CORE CURRICULUM 13, available at <http://www.emsc.nysed.gov/ciai/mst/sci/documents/livingen.pdf>.

82. *Id.*

83. *Id.* at 14.

84. N. J. DEP.T OF EDUC., NEW JERSEY CORE CURRICULUM CONTENT STANDARDS FOR SCIENCE 40 (2009), available at [http://www.state.nj.us/education/cccs/2009/std5\\_science.doc](http://www.state.nj.us/education/cccs/2009/std5_science.doc).

85. *Id.*

86. NEIL A. CAMPBELL, ET AL., *BIOLOGY: CONCEPTS AND CONNECTIONS* 279 (4<sup>th</sup> ed. 2003).

Likewise, Holt's *Life Science* asks students to only consider how "organisms can be compared to support the theory of evolution[.]" or "how fossils provide evidence that organisms have evolved."<sup>87</sup> No opportunity is offered to encourage students to critically evaluate the theory and explore potential weaknesses in neo-Darwinism.

Sylvia S. Mader's *Essentials of Biology* carefully steers students away from any meaningful, critical thought about evolution by asking students to "[e]xplain why evolution is no longer considered a hypothesis."<sup>88</sup> For students who cannot regurgitate from the text, the proper "answer" is given directly below the question, up-side-down, so students are not required to hunt for the "correct" answer.<sup>89</sup> Mader's answer states that "[e]volution is supported by many diverse and independent lines of evidence."<sup>90</sup> Again, no opportunity is given to students to challenge or explore counter-arguments to evolution.

Other textbooks such as Raven, Johnson, Losos, and Singer's *Biology*, do not even ask questions allowing students to evaluate the evidence, instead they make dogmatic claims like, "the evidence for Darwin's theory has become overwhelming" because "information from many different areas of biology—fields as different as anatomy, molecular biology, and biogeography—is only interpretable scientifically as the outcome of evolution."<sup>91</sup>

Kenneth Miller and Joseph Levine's *Biology* provides yet another example of the faux inquiry-based learning employed when teaching evolution. The textbook recommends that teachers ask students, "Why do you think many scientists infer that birds evolved from dinosaurs?" implying that "scientists" would not challenge this hypothesis, even though some leading scientists have challenged the hypothesis that birds evolved from dinosaurs.<sup>92</sup> Miller and Levine show the kind of inquiry commonly implemented in evolution instruction by asking, "[w]hat are the two alternative explanations for the evolution of modern birds?"<sup>93</sup> Such a false choice does not encourage students to think outside of the evolutionary box created by the text; it encourages students to fundamentally take neo-Darwinian evolution as a given.

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87. HOLT SCIENCE & TECHNOLOGY, *LIFE SCIENCE: CALIFORNIA EDITION* 176 (2001).

88. SYLVIA S. MADER, *ESSENTIALS OF BIOLOGY* 225 (1<sup>st</sup> ed. 2007).

89. *Id.*

90. *Id.*

91. PETER H. RAVEN, ET AL, *BIOLOGY*, 453 (7th ed. 2005).

92. KENNETH R. MILLER & JOSEPH S. LEVINE, *BIOLOGY* 807 (Teacher's ed. 2008). For critics of the hypothesis that birds evolved from dinosaurs, see ALAN FEDUCCIA, *THE ORIGIN AND EVOLUTION OF BIRDS* (2<sup>nd</sup> ed. 1999); Devon E. Quick & John A. Ruben, *Cardio-Pulmonary Anatomy in Theropod Dinosaurs: Implications From Extant Archosaurs*, 270 *J. OF MORPHOLOGY* 1232 (2009); Frances C. James & John A. Pourtless IV, *Cladistics and the Origins of Birds: A Review and Two New Analyses*, 66 *ORNITHOLOGICAL MONOGRAPHS* 1 (2009).

93. MILLER & LEVINE, *supra* note 92, at 807.

Many additional textbook examples could be given, but this matter is ultimately resolved upon the following questions: *Will schools teach neo-Darwinian evolution as a dogma to be accepted but never questioned, or will they teach it as a science that is open to rigorous scientific investigation, inquiry, and debate?* This author feels evolution can and should be taught as a science—encouraging students to truly explore the evidence for and against modern neo-Darwinian theory to form their own views. However, while leading science education authorities frequently laud inquiry-based instruction, they effectively jettison such pedagogical approaches to science education when recommending standards for teaching evolution, expecting students to learn neo-Darwinian evolution as unadulterated fact. Such evolution-education standards make their way into state science standards, which in turn influence textbooks and the classroom learning experience. The result: dumbed-down teaching of evolution as a dogma, not as a science. This is harmful to students because it does not foster scientific literacy, it does not teach them to think scientifically or skeptically about modern theories of biological origins, and it does not give them the mental tools or adequate access to the data to make up their minds on these fundamental questions about origins.

More pragmatically, teaching neo-Darwinism as unquestioned fact discourages curious minds from investigating fundamental questions about the sufficiency of modern evolutionary thinking. This has the effect of squashing student interest in pursuing science and impedes the progress of science. Whether students ultimately accept evolution or not, the result is a population that is *less* scientifically literate and is *less* interested in pursuing careers in science. Thus, teaching evolution dogmatically works directly against any attempts to solve the stated problems facing American science and science education today. Teaching evolution scientifically, however, could be the exact antidote needed to increase scientific literacy and foster student interest in studying and pursuing science—directly helping to solve current crises in American science education.

### **III. IS IT LEGAL TO TEACH NEO-DARWINISM CRITICALLY?**

There are two types of policies commonly adopted to implement the inquiry method when teaching evolution. Some policies are compulsory, requiring students to engage in critical analysis when studying evolution. Other policies, commonly called academic freedom policies, are permissive, giving teachers the instructional freedom to allow students to learn about both the scientific evidence for and against evolution should they choose to exercise it. As discussed in the following sections, both approaches are firmly constitutional.

### A. THE CONSTITUTIONALITY OF REQUIRING CRITICAL ANALYSIS OF EVOLUTION

A variety of authorities point toward the constitutionality of requiring public school science classrooms to critically investigate evolution. A comprehensive review of the case law surrounding the teaching of biological origins in public schools reveals that various cases have: 1) upheld the teaching of evolution, 2) struck down the teaching of creationism, or 3) struck down the use of religiously-oriented evolution-disclaimers. However, not a single court ruling stands for the proposition that it is unconstitutional to subject evolution to scientific critique in public schools.<sup>94</sup> To the contrary, in *Edwards v. Aguillard*, the Supreme Court effectively affirmed that scientific critique of evolution is not illegal, stating: “We do not imply that a legislature could never require that scientific critiques of prevailing scientific theories be taught.”<sup>95</sup> The teaching of evolution was the precise context in which the Court made that statement.

To pass the *Lemon* test, government policies must have both a “secular legislative purpose” and a primary effect which “neither advances nor inhibits religion.”<sup>96</sup> Public school governing authorities have little difficulty finding strong secular legislative purposes for teaching evolution critically.

#### *1. Secular Purposes and Secular Effects Justify Requiring Critical Analysis of Evolution*

In *Edwards*, the U.S. Supreme Court found a legitimate purpose to be a “clear secular intent of enhancing the effectiveness of science instruction.”<sup>97</sup> As elaborated in Part II, teaching evolution scientifically—requiring students to study evolution through inquiry and critical analysis of modern evolutionary thinking—can have many beneficial pedagogical effects. Educational authorities can readily justify teaching evolution critically by expressing a bona fide motive to achieve those pedagogical benefits.

Teaching students about scientific viewpoints that critique the prevailing neo-Darwinian paradigm of evolutionary biology informs students about the scientific method. In fact, a strong argument can be made

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94. See Casey Luskin, *Does Challenging Darwin Create Constitutional Jeopardy? A Comprehensive Survey of Case Law Regarding the Teaching of Biological Origins*, 32 HAMLIN L. REV. 1 (2009).

95. *Edwards v. Aguillard*, 482 U.S. 578, 592-93 (1987) (declaring creationism unconstitutional because it advocates the “religious belief that a supernatural creator was responsible for the creation of humankind” *Id.* at 592).

96. *Lemon v. Kurtzman*, 403 U.S. 602, 612-13 (1971) (citing *Board of Education v. Allen*, 392 U.S. 236, 243 (1968)). “First, the statute must have a secular legislative purpose; second, its principal or primary effect must be one that neither advances nor inhibits religion, finally, the statute must not foster ‘an excessive government entanglement with religion.’”

97. *Edwards*, 482 U.S. at 593-94.

that teaching evolution uncritically *fails* to teach evolution as a science, and instead elevates it to the level of a dogma. As suggested in Part II, there are many reasons why teaching evolution critically will enhance the effectiveness of science education. A legitimate secular purpose to achieve any of the following secular effects would justify teaching evolution critically:

- By studying both the evidence for and against evolution, students learn more about biology and the science pertaining to evolution.
- By understanding the ways that scientists support or challenge evolution, students gain an appreciation for the tentative nature of scientific knowledge, better understand the methods used by scientists, and practice the habits of mind employed by scientists—learning to develop open-minded, skeptical, and non-dogmatic scientific minds.
- By logically and critically evaluating the evidence for and against evolution, students improve critical thinking skills and hone their ability to reject false arguments or accept valid ones.
- By identifying assumptions inherent in the arguments for evolution and considering alternative hypotheses to prevailing neo-Darwinian theories of evolution, students learn to understand how scientific theories are built and how scientists justify their explanations.
- By learning about the scientific disagreement over prevailing theories of evolution, students will naturally increase their interest in science and be inspired to pursue careers in science with the hopes of contributing to or resolving these debates.
- By treating evolution in a nondogmatic fashion, teachers will naturally defuse the community controversy that commonly surrounds the teaching of evolution.

In addition, it goes without saying that there would be a much greater and more important secular effect of teaching evolution critically, namely that the populace has a higher degree of scientific literacy and is thereby more likely to support scientific initiatives as a society.

## *2. Legislative Precedent Supports Teaching Evolution Scientifically*

The legitimacy of teaching the controversy over evolution can also find a strong precedent in statements and policies adopted by government bodies that have stood the test of time without any lawsuits. A prime example is the “Santorum Amendment.” In 2001, the U.S. Congress adopted language

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into the conference report of the No Child Left Behind Act, which approves teaching students about scientific disagreement over biological evolution:

[A] quality science education should prepare students to distinguish the data and testable theories of science from religious or philosophical claims that are made in the name of science. Where topics are taught that may generate controversy (such as biological evolution), the curriculum should help students to understand the full range of scientific views that exist, why such topics may generate controversy, and how scientific discoveries can profoundly affect society.<sup>98</sup>

That language was based upon a resolution that passed the U.S. Senate by a vote of 91–8.<sup>99</sup> The U.S. Department of Education affirmatively stated regarding the resolution that, “The [D]epartment, of course, embraces the general principles – reflected in the Senate Resolution – of academic freedom and inquiry into scientific views and theories.”<sup>100</sup>

Under the Santorum Resolution language, students are encouraged to learn about why evolution generates controversy so they can become informed participants in public discussions. To learn about and discuss any controversy over evolution facially implies that students must learn more than one side of the scientific issue. Permitting students to explore alternative scientific views so they can develop critical thinking skills is consistent with the recent trend towards inquiry-based science education.<sup>101</sup> Districts or teachers may cite directly to the Santorum Amendment and its support from the Department of Education, as secular justification for “teaching the controversy.” They may also cite to various state school boards who have already adopted policies supporting teaching the controversy, using any of the following policies as examples:

**Texas:** Students must “analyze, evaluate and critique scientific explanations . . . including examining all sides of scientific evidence of those scientific explanations so as to encourage critical thinking,” and also “analyze and evaluate” core evolutionary claims, including “common ancestry,” “natural selection,” “mutation,” “sudden appearance,” the origin of the “complexity of

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98. 147 Cong. Rec. S6147–48 (daily ed. June 13, 2001).

99. 147 Cong. Rec. S6153 (daily ed. June 13, 2001) (amendment submitted by Sen. Santorum) (“It is the sense of the Senate that: (1) good science education should prepare students to distinguish the data or testable theories of science from philosophical or religious claims that are made in the name of science; (2) where biological evolution is taught, the curriculum should help students to understand why this subject generates so much continuing controversy, and should prepare the students to be informed participants in public discussions regarding the subject.”).

100. Letter from Gene Hickock, Acting Deputy Secretary, U.S. Dept. of Education, to Linda McCulloch, Acting Montana Superintendent of Public Instruction (Mar. 8, 2004).

101. *See infra* notes 102–10.

the cell,” and the formation of “long complex molecules having information such as the DNA molecule for self-replicating life.”<sup>102</sup>

**Minnesota:** “The student will be able to explain how scientific and technological innovations as well as new evidence can challenge portions of or entire accepted theories and models including . . . [the] theory of evolution . . . .”<sup>103</sup>

**New Mexico:** Students will “critically analyze the data and observations supporting the conclusion that the species living on Earth today are related by descent from the ancestral one-celled organisms.”<sup>104</sup>

**Pennsylvania:** “Critically evaluate the status of existing theories (e.g., germ theory of disease, wave theory of light, classification of subatomic particles, theory of evolution, epidemiology of AIDS).”<sup>105</sup>

**Missouri:** “Identify and analyze current theories that are being questioned, and compare them to new theories that have emerged to challenge older ones (e.g., Theory of Evolution . . . ).”<sup>106</sup>

**Alabama:** “[E]volution by natural selection is a controversial theory . . . . Instructional material associated with controversy should be approached with an open mind, studied carefully, and critically considered.”<sup>107</sup>

**South Carolina:** “Summarize ways that scientists use data from a variety of sources to investigate and critically analyze aspects of evolutionary theory.”<sup>108</sup>

**Kansas:** “Regarding the scientific theory of biological evolution, the curriculum standards call for students to learn about the best evidence for modern evolutionary theory, but also to learn about

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102. 19 Tex. Admin. Code § 112.34 (2009), available at <http://ritter.tea.state.tx.us/rules/tac/chapter112/ch112c.pdf>.

103. MINN. ACADEMIC STANDARDS COMM., MINN. DEP’T. OF EDUC., MINNESOTA ACADEMIC STANDARDS, HISTORY AND NATURE OF SCIENCE, GRADES 9-12 16 (2003), available at <http://education.state.mn.us/mdeprod/groups/Standards/documents/LawStatute/000282.pdf>.

104. N. M. STATE DEP’T. OF EDUC., NEW MEXICO SCIENCE CONTENT STANDARDS, BENCHMARKS AND PERFORMANCE STANDARDS, Standard II (9) (2003), available at [http://sde.state.nm.us/MathScience/standards/science\\_standards.pdf](http://sde.state.nm.us/MathScience/standards/science_standards.pdf).

105. PENNSYLVANIA, ACADEMIC STANDARDS FOR SCIENCE AND TECHNOLOGY, Standard 3.2.12, available at <http://www.pacode.com/secure/data/022/chapter4/chap4toc.html>.

106. MO. STATE DEP’T. OF ELEMENTARY AND SECONDARY EDUC., MISSOURI SCIENCE STANDARDS 106 (2005), available at [http://www.dese.mo.gov/divimprove/curriculum/GLE/SciGLE\\_FINAL-4.2005.pdf](http://www.dese.mo.gov/divimprove/curriculum/GLE/SciGLE_FINAL-4.2005.pdf).

107. Ala. Dept. of Educ., State Bd. Res. (Nov. 8, 2001), available at [http://www.alsde.edu/html/boe\\_resolutions2.asp?id=309](http://www.alsde.edu/html/boe_resolutions2.asp?id=309).

108. SOUTH CAROLINA DEP’T. OF EDUC., SOUTH CAROLINA SCIENCE ACADEMIC STANDARDS, Standard 5, Indicator B-5.6 (2005), available at [http://ed.sc.gov/agency/offices/cso/standards/science/documents/ScienceStandardsNov182005\\_001.doc](http://ed.sc.gov/agency/offices/cso/standards/science/documents/ScienceStandardsNov182005_001.doc).

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areas where scientists are raising scientific criticisms of the theory.”<sup>109</sup>

**Ohio:** “Describe how scientists continue to investigate and critically analyze aspects of evolutionary theory. (The intent of this benchmark does not mandate the teaching or testing of intelligent design.)”<sup>110</sup>

Each of the foregoing policies are still in effect except for the last two; Kansas’s policy was repealed in 2007 after conservatives lost a majority on the State Board of Education, and Ohio’s policy was repealed in 2006 after its State Board of Education underwent a similar change. Nonetheless, none of these policies have incurred a single lawsuit challenging their constitutionality. This is significant because if evolution lobbyists feel that a policy is unconstitutional, they often waste little time in filing lawsuits; it took less than two months for attorneys working with the ACLU to help parents file a lawsuit after the Dover Area School Board passed its ID policy.

Critics may object that occasional policies that are clearly unconstitutional (such as those that ban the teaching of evolution or permit the teaching of creationism) have gone unchallenged and are still on the books. The difference between such patently unconstitutional policies and the ones advocated above<sup>111</sup> is that policies that ban the teaching of evolution or permit the teaching of creationism are toothless. Such policies have previously been targeted by lawsuits and wholly eviscerated by U.S. Supreme Court rulings.<sup>112</sup> To use an evolutionary analogy, they are vestigial and without function.

In contrast, there is good reason why policies that simply require scientific critique of evolution have not been subjected to a single legal challenge: The U.S. Supreme Court has already stated it is not impermissible to “require that scientific critiques of prevailing scientific theories be taught.”<sup>113</sup> Indeed, even the ACLU and Americans United for the Separation for Church and State have acknowledged that “any genuinely scientific evidence for or against any explanation of life may be taught.”<sup>114</sup>

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109. KAN. DEP’T. OF EDUC., 2005 KANSAS SCIENCE STANDARDS, at page ii (repealed 2007).

110. JOINT COUNCIL OF THE STATE BD. OF EDUC. AND THE OHIO BD. OF REGENTS , ACADEMIC CONTENT STANDARDS 37 (repealed 2006), available at [http://www.agpa.uakron.edu/p16/Ohio\\_Standards.pdf](http://www.agpa.uakron.edu/p16/Ohio_Standards.pdf).

111. See *supra* notes 102–10 and accompanying text.

112. See *Epperson v. Arkansas*, 393 U.S. 97 (1968) (effectively declaring it illegal to ban the teaching of evolution); *Edwards* , 482 U.S. at 578. (declaring the teaching of creationism unconstitutional.)

113. *Edwards*, 482 U.S. at 593.

114. Religion In The Public Schools: A Joint Statement Of Current Law, (April 12, 1995), available at <http://www.ed.gov/Speeches/04-1995/prayer.html>.

Given that evolution lobbyists have sued so many other types of policies, it is difficult to argue that the myriad of policies that require scientific critique of evolution have failed to attract lawsuits simply because evolution lobbyists have not gotten around to filing them yet.

Educational authorities that wish to teach evolution scientifically and critically thus have a variety of legitimate secular purposes to justify their actions and can expect to see a number of important secular effects. Moreover, they will be building their policies upon the precedent of a number of governmental bodies that have sanctioned teaching the scientific controversy over evolution without even incurring legal challenges.

#### B. THE CONSTITUTIONALITY OF ACADEMIC FREEDOM LEGISLATION

Whereas critical analysis policies found in the various states listed in the previous section require students to critically investigate evolution, academic freedom legislation takes a permissive approach. Support for this type of legislation has been inspired by a growing public awareness that existing law does not protect tenure and employment for public school teachers who present scientific challenges to controversial scientific theories, such as those covering biological origins. Thus, academic freedom legislation aims to provide rights and protection for teachers concerning scientific presentations on biological evolution. Between 2004 and 2008, academic freedom legislation was submitted in the legislatures of no fewer than ten states.<sup>115</sup>

##### *1. There is a Secular Need to Protect Inquiry-Based Science Education for Teachers Instructing Students in Controversial Scientific Theories Such as Evolution*

Academic freedom legislation comes in two basic forms. It can protect the rights of teachers concerning scientific presentations pertaining only to evolution, or it can protect the rights of teachers concerning scientific presentations pertaining to controversial scientific theories in general. Thus, academic freedom legislation can cover multiple scientific subjects and is not necessarily limited to protecting academic freedom only within the context of teaching evolution. But given the questions and controversy commonly associated with evolution, it is probably most pertinent to address such legislation specifically as it relates to the teaching of biological origins.

In the *Scopes* trial of the 1920s, public school teacher John T. Scopes was wrongly disciplined for teaching the scientific evidence in favor of the

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115. These states include Alabama, Maryland, Oklahoma, New Mexico, Florida, Louisiana, South Carolina, Missouri, Iowa, and Michigan.

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theory of evolution.<sup>116</sup> The right to teach the evidence supporting evolution is now safeguarded.<sup>117</sup> Today, however, the teachers whose academic freedom is in jeopardy are those who wish to discuss scientific criticisms of evolutionary theory and delve into discussions about controversial scientific debates. Thus, in a very real sense academic freedom legislation follows in the tradition of John T. Scopes himself when the high school biology teacher reportedly stated: “If you limit a teacher to only one side of anything, the whole country will eventually have only one thought. . . . I believe in teaching every aspect of every problem or theory.”<sup>118</sup>

Indeed, teachers in the state of Louisiana where academic freedom legislation passed into law expressed sentiments similar to Scopes’, expressing fears about their rights to teach evolution critically and objectively. According to a survey by the Associated Professional Educators of Louisiana (APEL):

- 48% of teachers were “concerned that teaching controversial material could affect your tenure, salary, promotions, or job security.”
- 50% did not “feel legally confident and free to teach alternative models and to critically examine every side of evolution.”
- 55% felt “intimidated regarding the teaching of the controversy surrounding origins.”<sup>119</sup>

Unfortunately, despite the existence of legitimate scientific debates involving modern Darwinian theory, the right of teachers to cover these debates is often in question.<sup>120</sup> As a result, there have been repeated cases around the country where professors, teachers and students have been intimidated, ridiculed or penalized for discussing scientific criticisms of the theories of chemical and biological evolution. For example:

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116. *Scopes v. State*, 289 S.W. 363 (Tenn. 1927).

117. See *Epperson*, 393 U.S. 97; *Wright v. Houston Indep. Sch. Dist.*, 366 F. Supp. 1208 (S.D. Tex. 1972); *Moore v. Gaston County Bd. of Educ.*, 357 F. Supp. 1037 (N.C. 1973); *Crowley v. Smithsonian Inst.*, 462 F. Supp. 725 (D.C. 1978); *Peloza v. Capistrano Unified Sch. Dist.*, 37 F.3d 517 (9th Cir. 1994), *cert. denied*, 515 U.S. 1173 (1995); *Moeller v. Schrenko*, 554 S.E.2d 198 (Ga. Ct. App. 2001).

118. John Angus Campbell and Stephen C. Meyer, *How Should Schools Handle Evolution?*, USA TODAY, August 14, 2005, (quoting John T. Scopes), available at [http://www.usatoday.com/news/opinion/editorials/2005-08-14-evolution-debate\\_x.htm](http://www.usatoday.com/news/opinion/editorials/2005-08-14-evolution-debate_x.htm).

119. ASSOCIATED PROFESSIONAL EDUCATORS OF LOUISIANA, A+PEL 2005 ACADEMIC FREEDOM SURVEY (2005), available at <http://www.apeeducators.org/associations/3635/files/Academic%20Freedom%20Survey%20Aug%202005%20DDW%20.pdf>.

120. See, *infra* notes 121–25 and accompanying text.

- In 1998 Minnesota high school teacher Rodney LeVake was removed from teaching biology after expressing skepticism about Darwin's theory. LeVake, who holds a master's degree in biology, agreed to teach evolution as required in the district's curriculum, but said he wanted to "accompany that treatment of evolution with an honest look at the difficulties and inconsistencies of the theory."<sup>121</sup>
- Roger DeHart, a public high school biology teacher in Washington State, was denied the right to have his students read articles from mainstream science publications that made scientific criticisms of certain pieces of evidence commonly used to support Darwinian theory. One of the forbidden articles was written by noted evolutionist Stephen Jay Gould. Although DeHart complied with this ban, he was later removed from teaching biology.<sup>122</sup>
- In Mississippi, chemistry professor Nancy Bryson was asked by Mississippi University for Women to resign as head of the Division of Science and Mathematics after she gave a lecture to honors students called "Critical Thinking on Evolution."<sup>123</sup> She remarked, "Students at my college got the message very clearly[:] do not ask any questions about Darwinism."<sup>124</sup>

There have been similar cases of such persecution throughout the nation. For example, in 2005, the president of the University of Idaho instituted a campus-wide classroom speech-code, where "evolution" was declared "the only curriculum that is appropriate" for science classes.<sup>125</sup> This was a direct attack designed to intimidate university scientists and educators who have expressed skepticism about neo-Darwinian evolution, such as University of Idaho microbiologist Scott Minnich.<sup>126</sup> If this climate of intellectual intolerance exists in the university, it is likely far worse in secondary public

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121. *LeVake v. Indep. Sch. Dist.*, 625 N.W.2d 502, 506 (Minn. Ct. App. 2001), *cert. denied*, 534 U.S. 1081 (2002) (internal citations omitted).

122. See JOHN G. WEST, *DARWIN DAY IN AMERICA: HOW OUR POLITICS AND CULTURE HAVE BEEN DEHUMANIZED IN THE NAME OF SCIENCE* 234-38 (2007).

123. See Texas State Board of Education Hearing Transcript at 505 (September 10, 2003).

124. *Id.*

125. Letter from Timothy P. White, President, University of Idaho, to the University of Idaho Faculty, Staff and Students, *available at* <http://www.president.uidaho.edu/default.aspx?pid=85947>.

126. Dr. Minnich is one of over 800 Ph.D. scientists that signed *A Scientific Dissent from Darwinism*, which declares, "[w]e are skeptical of claims for the ability of random mutation and natural selection to account for the complexity of life. Careful examination of the evidence for Darwinian theory should be encouraged." See *A Scientific Dissent from Darwinism*, Home Page, <http://www.DissentfromDarwin.org> (last visited Dec. 18, 2009).

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schools where teachers have even less academic freedom. Policymakers concerned with attacks upon teacher academic freedom and the harm that such attacks inflict upon the effectiveness of science instruction have every good reason to be concerned about upholding teacher academic freedom.

While academic freedom among teachers has some First Amendment protection at the university level,<sup>127</sup> below the university level the courts have held that teacher academic freedom is severely limited. The Seventh Circuit described this murky state of the law in *Zykan v. Warsaw Community School Corporation* where it observed “[l]ess clear are the precise contours of this constitutionally protected academic freedom, and particularly its appropriate role . . . [in] the secondary school.”<sup>128</sup> Yet that same year the Seventh Circuit found a “compelling state interest in the choice and adherence to a suitable curriculum” which implies “[i]t cannot be left to individual teachers to teach what they please.”<sup>129</sup>

According to the Supreme Court, a school board or administrators may impose “reasonable restrictions” on teacher speech in public school classrooms.<sup>130</sup> The test for constitutionally protected teacher expression “entails striking a balance between the interests of the teacher as a citizen, in commenting upon matters of public concern, and the interest of the State as an employer, in promoting the efficiency of the public services it performs through its employees.”<sup>131</sup> Courts have consistently held that restrictions upon speech are permissible if “reasonably related to legitimate pedagogical concerns.”<sup>132</sup> The Supreme Court has thus given government officials, including school officials, wide discretion to restrict teacher speech:

[W]e have consistently given greater deference to government predictions of harm used to justify restriction of [government] employee speech than to predictions of harm used to justify restrictions on the speech of the public at large.<sup>133</sup>

Some courts have held that when teaching biological origins, school administrators have the power to prevent teachers from teaching outside of the curriculum. In the case of Rodney LeVake, the Minnesota Court of Appeals found that his district’s prohibition on teaching scientific criticisms of evolution was permissible:

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127. *See Keyishian v. Bd. of Regents*, 385 U.S. 589 (1967).

128. *Zykan v. Warsaw Cmty. Sch. Corp.*, 631 F.2d 1300, 1304 (7<sup>th</sup> Cir. 1980).

129. *Palmer v. Bd. of Educ.*, 603 F.2d 1271, 1274 (7<sup>th</sup> Cir. 1979), *cert. denied*, 444 U.S. 1026 (1980).

130. *Hazelwood Sch. Dist. v. Kuhlmeier*, 484 U.S. 260, 267 (1988).

131. *Mt. Healthy City Sch. Dist. Bd. of Educ. v. Doyle*, 429 U.S. 274, 284 (1977) (*quoting Pickering v. Bd. of Educ.*, 391 U.S. 563, 568 (1968)).

132. *Kuhlmeier*, 484 U.S. at 273.

133. *Waters v. Churchill*, 511 U.S. 661, 673 (1994).

The classroom is a “marketplace of ideas,” and academic freedom should be safeguarded. But *LeVake*, in his role as a public school teacher rather than as a private citizen, wanted to discuss the criticisms of evolution. *LeVake*’s position paper established that he does not believe the theory of evolution is credible. Further, *LeVake*’s proposed method of teaching evolution is in direct conflict with respondents’ curriculum requirements . . . . Based on *LeVake*’s belief that evolution is not a viable theory, respondents’ concern about his inability to teach the prescribed curriculum was well-founded.<sup>134</sup>

It should be noted that *LeVake* is sometimes mis-cited as holding that it is unconstitutional to teach scientific criticisms of evolution in public schools.<sup>135</sup> This case stands for no such proposition. At base, *LeVake* is an employment law case about the freedom of speech retained by a government employee when acting in the course of his employment. The Minnesota Court of Appeals did not attempt to make any determinations about the constitutionality of scientifically critiquing evolution in public schools. It simply balanced *LeVake*’s academic freedom rights to offer material outside the curriculum against the interests of the school district to wield tight control over the curriculum.

Case law suggests that under most circumstances, teachers below the university level do not have the academic freedom to go against reasonable district policies. Because academic freedom is limited below the university level, teachers would find it difficult to overcome reasonable restrictions from a district which prevents discussing scientific critique of evolution. Given the state of the law, it is completely legitimate—and constitutional—for a state legislature or local district to seek to protect, via statute or other policy, the academic freedom rights of teachers and professors to teach about the scientific evidence for and against controversial scientific theories, including evolution.

Academic freedom legislation specifically protects a right to teach “scientific critiques of prevailing scientific theories” that was identified by the Supreme Court in *Edwards*.<sup>136</sup> As previously noted, groups with widely divergent views on the Establishment Clause issued a “Joint Statement of Current Law” in 1995 that made clear under current law, “any genuinely scientific evidence for or against any explanation of life may be taught.”<sup>137</sup> Organizations endorsing this statement included the American Civil

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134. *LeVake*, 625 N.W.2d at 508–09 (Minn. Ct. App. 2001) (internal citations omitted).

135. This has been the author’s experience when assisting teachers who faced opposition from administrators that sought to shut down the presentation of scientific criticisms of evolution in the classroom.

136. *Edwards*, 482 U.S. at 592 (declaring creationism unconstitutional because it advocates the “religious belief that a supernatural creator was responsible for the creation of humankind”).

137. Religion in the Public Schools: A Joint Statement of Current Law, *supra* note 114.

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Liberties Union (ACLU) and Americans United for Separation of Church and State. Indeed, after an academic freedom bill passed into law in Louisiana in 2008, ACLU Executive Director Marjorie Esman reportedly acknowledged that “if the Act is utilized as written, it should be fine; though she is not sure it will be handled that way.”<sup>138</sup> Likewise, a similar policy adopted in a public school parish in northern Louisiana in 2006, drew an admission from an attorney working with the ACLU that, “[o]n its face,” the policy “is not objectionable.”<sup>139</sup>

## 2. *Academic Freedom Policies Have a Secular Effect of Improving Science Education*

Most academic freedom bills have not singled out evolution for special treatment; even if one did, it would not be unconstitutional. Thus, the Louisiana Science Education Act states that public schools should “create and foster an environment within public elementary and secondary schools that promotes critical thinking skills, logical analysis, and open and objective discussion of scientific theories being studied including, but not limited to, evolution, the origins of life, global warming, and human cloning.”<sup>140</sup> Similarly, an academic freedom policy passed by Ouachita Parish, Louisiana states:

[T]he teaching of some scientific subjects, such as biological evolution, the chemical origins of life, global warming, and human cloning, can cause controversy . . . . [T]eachers shall be permitted to help students understand, analyze, critique, and review in an objective manner the scientific strengths and weaknesses of existing scientific theories pertinent to the course being taught.<sup>141</sup>

Thus, adopted academic freedom policies cover multiple scientific subjects and are not limited to protecting academic freedom solely within the context of teaching biological origins.

Academic freedom legislation seeks to ensure that public school educators have the right to present constitutionally permissible scientific information on the topic. As noted, it is perfectly legal for a teacher to present students with scientific critiques of prevailing scientific theories, including evolutionary theory. The effect of this legislation is to protect teacher academic freedom, thereby giving teachers confidence and

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138. WWLTV.com, *ACLU Plans To Keep Eye On Science Bill* (June 24, 2008), <http://www.wwltv.com/local/stories/wwl062408tpscienceact.37767059.html>.

139. Barbara Leader, *School Board Commended for Science Education*, NEWS STAR, December 1, 2006 at 1B (on file with author).

140. La. Rev. Stat. Ann. § 17:285.1(B)(1) (2008).

141. BD. OF EDUC. OF OUACHITA PARISH, *OUCHITA PARISH SCIENCE CURRICULUM POLICY* (La. 2006), available at [http://www.opsb.net/downloads/forms/Ouachita\\_Parish\\_Science\\_Curriculum\\_Policy.pdf](http://www.opsb.net/downloads/forms/Ouachita_Parish_Science_Curriculum_Policy.pdf).

assurance that they can inform students about the scientific evidence pertaining to controversial scientific theories without fear of reprisal. This combats any fear that teachers may have which prevents them from effectively teaching controversial scientific subjects. Students thus receive greater access to scientific information, allowing them to become better-informed, scientifically literate citizens who are capable of participating in civic dialogue on controversial scientific subjects. As they wrestle with the scientific data on these controversial scientific questions, students also gain improved critical thinking skills. Students' rights to hold positions on controversial scientific theories can also be protected under academic freedom legislation.<sup>142</sup>

The ACLU representatives quoted above admitted that facially, these policies are constitutional. This is likely due to the fact that academic freedom legislation expressly does *not* protect the advocacy of any religious viewpoint, as seen in a representative provision taken from the Louisiana Science Education Act:

This Section shall not be construed to promote any religious doctrine, promote discrimination for or against a particular set of religious beliefs, or promote discrimination for or against religion or nonreligion.<sup>143</sup>

Simply put, such legislation does not cover nor protect the teaching of religion. Were a teacher to advocate religion in the classroom, such a law would not protect their actions. The legislation "only protects the teaching of scientific information" such as "the scientific strengths and . . . weaknesses of existing scientific theories covered in the course being taught."<sup>144</sup> Under such language, there is no way that it could endorse or protect the advocacy of religion. Such language also makes it unlikely that academic freedom legislation would be subject to an applied challenge.

#### C. RESPONSES TO COMMON OBJECTIONS TO TEACHING EVOLUTION SCIENTIFICALLY

Teaching the controversy over evolution can be done under legitimate secular legislative purposes that evince a clear secular intent of enhancing the effectiveness of science instruction and lead to a variety of legitimate

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142. See *Tinker v. Des Moines Indep. Cmty. Sch. Dist.*, 393 U.S. 503, 508–11 (1969) (holding that students had the right to express their opinions in a public school setting by wearing certain non-disruptive clothing because "state-operated schools may not be enclaves of totalitarianism" and "[i]n the absence of a specific showing of constitutionally valid reasons to regulate their speech, students are entitled to freedom of expression of their views").

143. La. Rev. Stat. Ann. § 17:285.1(D) (2008).

144. For example, see the 2009 Oklahoma Academic Freedom Bill, SB 320, 52<sup>nd</sup> Leg., 1<sup>st</sup> Sess. (Okla. 2009).

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secular effects.<sup>145</sup> Nonetheless, critics make a variety of objections to teaching critical analysis of evolution in public schools, many of which attempt to misrepresent the pedagogical strategy as an attempt to foist religion upon students. Some of these objections will be dealt with below.

*1. Courts Reject the Argument that it is Inappropriate to “Single Out” Evolution*

First Amendment scholar Steven D. Smith argues that investigation into legislative purpose encouraged by the *Lemon* test and other Establishment Clause doctrines invites a “discourse of demonization,” because it makes “‘motive’ or ‘purpose’ dispositive of constitutionality [and thus] inevitably encourages opponents of a particular law to try to show the law was animated by religious hostility or bigotry.”<sup>146</sup> According to Smith, this results in “a constitutional discourse in which adversaries try to demonize each other or to portray each other in the worst plausible light.”<sup>147</sup>

This present author agrees with Smith’s contention. The intense and widespread use of *ad hominem* attacks against skeptics of Darwinism, and the obsession many evolution lobbyists display regarding the religious motives, beliefs, and affiliations of Darwin-skeptics seems to be inspired by the judicial scrutiny of religious motives by Darwin-skeptics in cases like *Epperson*, *McLean v. Arkansas*, *Edwards v. Aguillard*, *Kitzmiller v. Dover*, and others. Following courts that investigated legislative purpose,<sup>148</sup> opponents of TES policies have sought to assert improper motives underlying constitutionally legitimate policies that teach evolution critically. In particular, it is argued that educational policies that only pertain to evolution somehow “single out” evolution, thereby exposing an allegedly hidden religious purpose behind the policy. Various courts—including at least one higher court—have rejected this argument.

In *Freiler v. Tangipahoa Parish Board of Education*, the Fifth Circuit Court of Appeals dealt with a lawsuit over an evolution-disclaimer, and validated a secular purpose underlying the disclaimer “to disclaim any orthodoxy of belief that could be inferred from the exclusive placement of evolution in the curriculum, and . . . to reduce offense to the sensibilities and sensitivities of any student or parent caused by the teaching of

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145. See *supra* Section III (A)(B).

146. STEVEN D. SMITH, GETTING OVER EQUALITY: A CRITICAL DIAGNOSIS OF RELIGIOUS FREEDOM IN AMERICA 116 (2001).

147. *Id.*

148. See *Epperson v. Arkansas*, 393 U.S. 97 (1968), *Edwards v. Aguillard*, 483 U.S. 578 (1987); *Freiler v. Tangipahoa Parish Bd. of Educ.* 185 F3d. 337 (5th Cir. 1999), *cert. denied*, 530 U.S. 1251 (2000) (striking down the disclaimer on other grounds); *McLean v. Ark. Bd. Of Educ.* 529 F. Supp. 1255 (Ark. 1982); *Kitzmiller v. Dover Area Sch. Dist.*, 400 F. Supp. 2d 707 (M.D.P.A. 2005).

evolution.”<sup>149</sup> The Fifth Circuit noted that “a purpose is no less secular simply because it is infused with a religious element,”<sup>150</sup> and thus “the fact that evolution, the subject about which the School Board sought to disclaim any orthodoxy of belief, is religiously charged . . . and the fact that sensitivities and sensibilities to which the School Board sought to reduce offense are religious in nature, does not *per se* establish that those avowed purposes are religious purposes.”<sup>151</sup> The court explicitly validated these legislative purposes because “local school boards need not turn a blind eye to the concerns of students and parents troubled by the teaching of evolution in public classrooms.”<sup>152</sup>

Likewise, in her dissent from a denial of rehearing of *Freiler*, Fifth Circuit Judge Barksdale argued that because many students in the district held beliefs that conflicted with evolution, it was not inappropriate for the parish “to give context to the message, but without promoting that concept or expressing intolerance for any other [viewpoint].”<sup>153</sup>

Similarly, in *Selman v. Cobb County*, plaintiffs argued that the district was inappropriately singling out evolution in a disclaimer, evidence of a religious purpose.<sup>154</sup> But the court (in a decision that was later vacated on other grounds) rejected this argument because “evolution is the only theory of origin being taught in Cobb County classrooms” and “evolution was the only topic in the curriculum, scientific or otherwise, that was creating controversy at the time of the adoption of the textbooks and Sticker.”<sup>155</sup> Thus the court noted that “[t]he School Board’s singling out of evolution is understandable in this context.”<sup>156</sup> The court then found two legitimate secular purposes for the sticker. The sticker was permissible because the purpose of “[f]ostering critical thinking is a clearly secular purpose . . . .

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149. *Freiler*, 185 F.3d at 344.

150. *Id.* at 345.

151. *Id.*

152. *Id.* at 346.

153. *Freiler v. Tangipahoa Parish Bd. of Educ.*, 201 F.2d 602, 607 (5th Cir. 2000), *cert. denied*, 530 U.S. 1251 (2000).

154. *Selman*, 390 F. Supp. 2d 1286, 1302-03 (N.D. Ga. 2005) *vacated and remanded*, *Selman v. Cobb County Sch. Dist.*, 449 F.3d 1320 (11<sup>th</sup> Cir. 2006). The disclaimer stated: “This textbook contains material on evolution. Evolution is a theory, not a fact, regarding the origin of living things. This material should be approached with an open mind, studied carefully, and critically considered.” Though I feel this unremarkable disclaimer should be unquestionably constitutional, I oppose policies that adopt disclaimers because they are ineffective and controversial pedagogical tools. Nor would I recommend adopting the controversial “evolution is a theory, not a fact” language into any educational policy. See Casey Luskin, Is “Evolution” a “Theory” or “Fact” or Is This Just a Trivial Game of Semantics?, <http://www.discovery.org/a/6401> (last visited Nov. 28, 2009).

155. *Selman*, 390 F. Supp. 2d at 1302-03. For further commentary on this case, see Luskin, *supra* note 94, at 53–56; Francis J. Beckwith, *The Court of Disbelief: The Constitution’s Article VI Religious Test Prohibition and the Judiciary’s Religious Motive Analysis*, 33 HASTINGS CONST. L. Q. 337 (2006).

156. *Selman*, 390 F. Supp. 2d at 1303.

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[and] because [the disclaimer] tells students to approach the material on evolution with an open mind, to study it carefully, and to give it critical consideration.”<sup>157</sup> Additionally, “presenting evolution in a manner that is not unnecessarily hostile” in order to “reduce[] offense to students and parents whose beliefs may conflict with the teaching of evolution”<sup>158</sup> was held to be a permissible purpose.

The only court ruling to buy the “singling out” evolution argument was *Kitzmiller v. Dover*, a ruling with numerous problems too great to catalogue here.<sup>159</sup> However, it is noteworthy that the authority that Judge Jones relied on to validate the “singling out” evolution argument was the (now vacated) *Selman* decision<sup>160</sup> which contra Judge Jones in fact rejected the “singling out” evolution argument on the grounds that “[t]he School Board’s singling out of evolution is understandable”<sup>161</sup> because “evolution was the only topic in the curriculum, scientific or otherwise, that was creating controversy,”<sup>162</sup> further finding that the school board’s policy passed the purpose prong of the *Lemon* test. Judge Jones seems to have chosen the wrong authority to validate the “singling out evolution” argument.

Thus, the purposes of encouraging critical thinking, disclaiming orthodoxy of belief, and reducing student/parent offense from teaching evolution, were all found to be legitimate secular purposes for crafting evolution policies. These legitimate secular purposes rebut the charge that “singling-out” evolution for special treatment in educational policies necessarily implies some kind of unconstitutional hidden religious purpose on the part of policymakers.

## 2. *Teaching Evolution Critically is Not a Post-Kitzmiller Policy Innovation*

As part of a strategy to link inquiry-based evolution-education with religion, opponents of TES policies have tried to paint critical analysis of evolution as a policy approach that arose as a “fallback strategy” after the *Kitzmiller v. Dover* in Pennsylvania ruling struck down the teaching of intelligent design as religion. For instance, a presentation before the NAS by Jay Labov of the National Academy’s Center for Education asserts that

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157. *Id.* at 1302.

158. *Id.* at 1305.

159. See Jay D. Wexler, *Kitzmiller and the “Is It Science?” Question*, 5 FIRST AMEND. L. REV. 90, 93 (2006); Arnold H. Loewy, *The Wisdom and Constitutionality of Teaching Intelligent Design in Public Schools*, 5 FIRST AMEND. L. REV. 82 (2006); David K. DeWolf, et al., *Intelligent Design Will Survive Kitzmiller v. Dover*, 68 MONT. L. REV. 7, 14–17 (2007); Luskin, *supra* note 94; John G. West & David K. DeWolf, *A Comparison of Judge Jones’ Opinion in Kitzmiller v. Dover with Plaintiffs’ Proposed “Findings of Fact and Conclusions of Law”*, Dec. 12, 2006, <http://www.discovery.org/scripts/viewDB/filesDB-download.php?command=download&id=1186>.

160. *Kitzmiller*, 400 F. Supp. 2d at 732.

161. *Selman*, 390 F. Supp. 2d at 1303.

162. *Id.* at 1302–03.

in the “Post-Dover Landscape,” there are “[a]ttempts to rewrite language in legislation that are now emphasizing critical analysis.”<sup>163</sup> Likewise, an article co-authored by former NCSE spokesman Nicholas Matzke, asserts that critical analysis of evolution is a “Fallback Antievolutionist Strategy.”<sup>164</sup> The article attempts to paint critical analysis of evolution as a post-Dover tactic:

Given the defeat of intelligent design in *Kitzmiller v. Dover* in 2005, what can we expect to see next by way of creationist attacks?

It appears certain that the main challenge to teaching evolution in public schools will be educational policies that propose critical analysis and similar invocations of critical thinking—specifically in connection with evolution-related science.<sup>165</sup>

But is it correct to insinuate that critical analysis of evolution is linked to a “defeat of intelligent design” in the *Kitzmiller v. Dover* ruling? In fact, the Dover ruling was issued in 2005, and the history of pre-Dover public policy debates over teaching evolution makes it very difficult to seriously argue that critical analysis of evolution is a post-Dover “fallback” position.

Since its first involvement with a major public policy battle in 2001 and 2002 in Ohio, Discovery Institute opposed mandating the teaching of ID in public schools and instead has recommended teaching critical analysis of evolution. This position is a matter of public record. In a March 2002 op-ed in the *Cincinnati Enquirer*, Stephen C. Meyer, director of Discovery Institute’s Center for Science and Culture, published an op-ed explaining Discovery Institute’s recommended science education policy:

Recently, while speaking to the Ohio State Board of Education, I suggested this approach as a way forward for Ohio in its increasingly contentious dispute about how to teach theories of biological origin, and about whether or not to introduce the theory of intelligent design alongside Darwinism in the Ohio biology curriculum.

First, I suggested—speaking as an advocate of the theory of intelligent design—that Ohio not require students to know the scientific evidence and arguments for the theory of intelligent design, at least not yet.

Instead, I proposed that Ohio teachers teach the scientific controversy about Darwinian evolution. Teachers should teach

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163. Jay Labov, Challenges to Teaching and Learning About Evolution: A National Perspective, [http://www7.nationalacademies.org/DBASSE/Labov\\_NSTA\\_Presentation\\_PDF.pdf](http://www7.nationalacademies.org/DBASSE/Labov_NSTA_Presentation_PDF.pdf) (last visited Jan. 24, 2010).

164. Nicholas J. Matzke & Paul R. Gross, *Analyzing Critical Analysis: The Fallback Antievolutionist Strategy*, in NOT IN OUR CLASSROOMS: WHY INTELLIGENT DESIGN IS WRONG FOR OUR SCHOOLS 28 (Eugenie C. Scott & Glenn Branch, eds. 2006).

165. *Id.* at 29.

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students about the main scientific arguments for and against Darwinian theory. And Ohio should test students for their understanding of those arguments, not for their assent to a point of view.<sup>166</sup>

Discovery Institute was thus on the record—since its first involvement in a major public policy battle, years before Dover—as opposing the mandatory inclusion of ID in the public school curriculum and instead recommending critical analysis of evolution.

Discovery Institute's position was consistent in the subsequent years, as it recommended critical analysis of evolution in Ohio in 2004<sup>167</sup> and in Wisconsin in 2004.<sup>168</sup> Similarly, from the beginning of the Dover incident, Discovery Institute opposed Dover's attempts to mandate ID.<sup>169</sup>

The Dover Area School Board passed its policy requiring the teaching of ID on October 18, 2004. On October 6, 2004, Discovery Institute issued a statement explaining that it opposed Dover mandating ID:

[A] recent news report seemed to suggest that the Center for Science & Culture endorses the adoption of textbook supplements teaching about the scientific theory of intelligent design (ID), which simply holds that certain aspects of the universe and living things can best be explained as the result of an intelligent cause rather than merely material and purposeless processes like natural selection. Any such suggestion is incorrect.<sup>170</sup>

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166. Stephen C. Meyer, *Teach the Controversy*, CINCINNATI ENQUIRER, Mar. 30, 2002, <http://www.discovery.org/a/1134><http://www.discovery.org/scripts/viewDB/index.php?command=view&id=1134>.

167. Discovery Inst., Ohio Votes 13–5 to Approve Lesson Plan Critical of Evolution (Mar. 9, 2004), <http://www.discovery.org/a/1898>. (“Chapman added that the lesson plan is exactly the approach to teaching evolution that Discovery Institute has advocated all along, helping students learn both the scientific strengths and weaknesses of Darwin’s theory. . . . The lesson plan does not discuss religion or alternative scientific theories such as intelligent design.”)

168. Discovery Inst., Wisconsin School Board Adopts Improved Policy Endorsing Fully Teaching Evolution, Not Creationism (Dec. 7, 2004), <http://www.discovery.org/a/2323>. (“[T]he school board of Grantsburg, Wisconsin adopted a revised policy on the teaching of evolution at a special meeting on December 6, which states that ‘Students shall be able to explain the scientific strengths and weaknesses of evolutionary theory[.]’ The new policy makes clear that the school board is not authorizing the teaching of either creationism or the scientific theory of intelligent design.”)

169. For a detailed discussion of how Discovery Institute opposed Dover’s ID policy and encouraged Dover not to adopt a policy advocating ID but instead adopt a policy that simply required critical analysis of evolution, see David K. DeWolf, et al., *Intelligent Design Will Survive Kitzmiller v. Dover*, 68 MONT. L. REV. 7, 14–17 (2007); Seth Cooper, Statement by Seth L. Cooper Concerning Discovery Institute and the Decision in *Kitzmiller v. Dover Area School Board Intelligent Design Case* (Dec. 21, 2005), [http://www.evolutionnews.org/2005/12/statement\\_by\\_seth\\_l\\_cooper\\_con.html](http://www.evolutionnews.org/2005/12/statement_by_seth_l_cooper_con.html).

170. Discovery Inst., Pennsylvania School District Considers Supplemental Textbook Supportive of Intelligent Design: Discovery Institute Continues to Recommend Fully Teaching Darwinian Evolution, Including Scientific Challenges to the Theory (Oct. 6, 2004), <http://discovery.org/a/2231>.

Discovery Institute's position did not change during the Dover lawsuit, and was reiterated multiple times in the coming months. Less than a month after Dover passed its ID-policy but before the ACLU filed any lawsuit, Discovery Institute's John West was quoted in an Associated Press story which described his view as stating "Discovery Institute . . . supports scientists studying intelligent-design theory, [but] opposes mandating it in schools."<sup>171</sup> Later, on the day that the plaintiffs filed their lawsuit against the Dover Area School Board, Discovery Institute again issued a statement opposing Dover's policy:

Apart from questions about its constitutionality, [Discovery Senior Fellow John] West expressed reservations about the Dover School Board's directive on public policy grounds.

"When we first read about the Dover policy, we publicly criticized it because according to published reports the intent was to mandate the teaching of intelligent design," explained West. "Although we think discussion of intelligent design should not be prohibited, we don't think intelligent design should be required in public schools."<sup>172</sup>

This was Discovery Institute's position both before and after Dover, as its education policy page states:

As a matter of public policy, Discovery Institute opposes any effort require the teaching of intelligent design by school districts or state boards of education. Attempts to mandate teaching about intelligent design only politicize the theory and will hinder fair and open discussion of the merits of the theory among scholars and within the scientific community. Furthermore, most teachers at the present time do not know enough about intelligent design to teach about it accurately and objectively.

Instead of mandating intelligent design, Discovery Institute seeks to increase the coverage of evolution in textbooks. It believes that evolution should be fully and completely presented to students, and they should learn more about evolutionary theory, including its unresolved issues. In other words, evolution should be taught as a scientific theory that is open to critical scrutiny, not as a sacred dogma that can't be questioned.<sup>173</sup>

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171. Martha Raffaele, Associated Press, Mandate to Teach 'Intelligent Design' as Evolution Alternate is Believed to Break Ground, MSNBC.com (Nov.12, 2004), <http://www.msnbc.msn.com/id/6470259/>.

172. Discovery Inst., Discovery Calls Dover Evolution Policy Misguided, Calls For its Withdrawal (Dec. 14, 2004), <http://www.discovery.org/scripts/viewDB/index.php?command=view&id=2341>.

173. Discovery Inst., Discovery Institute's Science Education Policy (June 18, 2008), <http://www.discovery.org/a /3164> (emphasis omitted).

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Critical analysis of evolution is no “post-Dover” or “fallback” educational policy position, at least as far as Discovery Institute is concerned.

### *3. Relabeling Scientific Critique of Evolution as “Creationism” Does Not Make It So*

As alluded to earlier, one tactic used by critics of TES policies is to claim that scientific critique of evolution is tantamount to advocating religion. Examples of this tactic are legion, and the argument can be made by innuendo or made explicitly. One extreme example comes from former NCSE staff member Nicholas Matzke who goes so far as to argue that:

All the critical analysis arguments are traceable to primary texts of the intelligent design (ID) and creation science (CS) movements. They are, without exception, aimed at promoting the sectarian doctrine of special creation.<sup>174</sup>

Courts have been clear that teaching creationism is unconstitutional.<sup>175</sup> By passively or actively conflating scientific critique of evolution with advocating “creationism,” opponents of TES policies like Matzke seek to scare policymakers into fearing that if evolution is subjected to any form of scientific criticism in the classroom, then somehow lawsuits will quickly follow.

While history has not borne out these threats, this present author witnessed this tactic used successfully before the Ohio State Board of Education in 2006. Thus an amusingly bold example of this tactic comes from Ohio evolutionary biology professor Patricia Princehouse who claimed that “critical analysis is intelligent design relabeled, just as intelligent design was creationism relabeled”<sup>176</sup> and “[c]ritical analysis is just another name for creationism.”<sup>177</sup> Are Princehouse’s arguments to be taken seriously? Even Matzke admitted that the actual text of Ohio’s now-repealed evolution standard was “generally thoughtful and correct.”<sup>178</sup>

A more recent example of the passive relabeling strategy comes from a 2009 article in *Evolution, Education, and Outreach* by NCSE staff members Louise S. Mead & Anton Mates. In their opening paragraph, Mead and Mates charge that “recent amendments to the Texas Educational Knowledge and Skills (TEKS) document now require the presentation of

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174. Matzke & Gross, *supra* note 164, at 29.

175. See *Edwards v. Aguillard*, 482 U.S. 578 (1987); *Webster v. New Lenox Sch. Dist.* #122, 917 F.2d 1004 (7th Cir. 1990); *McLean v. Ark. Bd. of Educ.*, 529 F. Supp. 1255 (D.C. Ark. 1982).

176. Jodi Rudoren, *Ohio Expected to Rein In Class Linked to Intelligent Design*, NEW YORK TIMES, February 14, 2006, (quoting Patricia Princehouse), [http://www.nytimes.com/2006/02/14/education/14evolution.html?\\_r=1&page\\_wanted=2](http://www.nytimes.com/2006/02/14/education/14evolution.html?_r=1&page_wanted=2).

177. Stephanie Simon, *Ohio Drops Demand that Evolution Be Challenged*, LOS ANGELES TIMES, February 15, 2006, (quoting Patricia Princehouse), <http://articles.latimes.com/2006/feb/15/nation/na-evolution15?pg=2>.

178. Matzke & Gross, *supra* note 164, at 31.

creationist claims about the complexity of the cell [and] the completeness of the fossil record.”<sup>179</sup> Apparently feeling the need to repeatedly use the word “creationist,” the article later states “Creationists on the Board of Education attempted unsuccessfully to replace this language but did add many other pieces of creationist jargon.”<sup>180</sup> The actual allegedly “creationist jargon” from the TEKS that was complained about includes the following:

- “in all fields of science, analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking by the student;”<sup>181</sup>
- “analyze and evaluate scientific explanations concerning any data of sudden appearance, stasis, and sequential nature of groups in the fossil record;”<sup>182</sup>
- “analyze and evaluate scientific explanations concerning the complexity of the cell;”<sup>183</sup>
- “analyze and evaluate the evidence regarding formation of simple organic molecules and their organization into long complex molecules having information such as the DNA molecule for self-replicating life;”<sup>184</sup> and
- “analyze and evaluate a variety of fossil types such as transitional fossils, proposed transitional fossils, fossil lineages, and significant fossil deposits with regard to their appearance, completeness, and alignment with scientific explanations in light of this fossil data . . . .”<sup>185</sup>

The implication of statements about “creationists” who “add many . . . pieces of creationist jargon” is that those standards advocate creationism. Since creationism is unconstitutional, the implication is that such standards are unconstitutional.

Yet the language in the new TEKS simply follows the proscription of

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179. Louise S. Mead & Anton Mates, *Why Science Standards are Important to a Strong Science Curriculum and How States Measure Up*, 2 *EVOLUTION, EDUCATION, AND OUTREACH* 359, 359 (2009).

180. *Id.* at 366.

181. Tex. Educ. Agency, Texas Essential Knowledge and Skills for Science, Subchapter C. High School, 112.32(c)(3)(A) (2009).

182. *Id.* at 112.32(c)(7)(B).

183. *Id.* at 112.32(c)(7)(G).

184. *Id.* at 112.32(c)(9)(D).

185. *Id.* at 112.32(c)(8)(A).

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many science education authorities to employ inquiry-based instruction within science education.<sup>186</sup> Is it truly unreasonable to ask students to “analyze and evaluate” the evidence for evolution? Are we seriously expected to believe that it is unconstitutional to require students to “analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking[?]” This language was adopted by an overwhelming majority of the Texas State Board of Education, supported by multiple board members who are publicly avowed evolutionists that adamantly opposed teaching creationism. To put it bluntly, critics who equate teaching evolution scientifically with advocating creationism are not making serious arguments.

Similar arguments have been used to oppose academic freedom legislation. When the Louisiana Academic Freedom bill (ultimately passed into law) was making its way through the Louisiana State Legislature in 2008, Barbara Forrest, professor of philosophy at Southeastern Louisiana State University and NCSE Board member, issued “Talking Points Opposing HB 1168” and “Backgrounder House Bill 1168”<sup>187</sup> for use by activists opposing the bill. Forrest’s talking points repeatedly asserted that the bill used “creationist code language” and promoted “stealth creationism.” One of her handouts uses the word “code” over 20 times.<sup>188</sup> Her attacks on the law even went so far as to assert that “[t]his bill will permit the teaching of creationism.”<sup>189</sup>

The operative language of the bill, filed by Democratic State Senator Ben Nevers, stated that teachers shall be “permitted to help students understand, analyze, critique, and review in an objective manner the scientific strengths and scientific weaknesses of existing scientific theories pertinent to the course being taught.”<sup>190</sup> Further, the bill was filed with language clearly stating that it “only protects the teaching of scientific information” and “shall not be construed to promote any religious doctrine, promote discrimination for or against a particular set of religious beliefs, or promote discrimination for or against religion or non-religion.”<sup>191</sup> Similar language was adopted into the final law that was passed by an overwhelming bipartisan majority in both houses of the Louisiana State

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186. See, e.g. *infra* note 190 and accompanying text.

187. See Barbara Forrest, Talking Points Opposing HB 1168, Apr. 27, 2008, [http://www.creationismstrojanhorse.com/HB\\_1168\\_Talking\\_Points.pdf](http://www.creationismstrojanhorse.com/HB_1168_Talking_Points.pdf); Barbara Forrest, HB 1168 Backgrounder, Apr. 27, 2008 (on file with author).

188. See Barbara Forrest, HB Backgrounder, Apr. 27, 2008, (on file with author).

189. Forrest, *supra* note 187.

190. SB 561(B), 2008 Gen. Assem., Reg. Sess., (La. 2008).

191. SB 561(E), 2008 Gen. Assem., Reg. Sess., (La. 2008).

Legislature.<sup>192</sup>

When the bill passed into law, Barry Lynn of Americans United for the Separation of Church and State declared, “It’s time for Louisiana to step into the 21st century and stop trying to teach religion in public schools . . . . Laws like this are an embarrassment.”<sup>193</sup> Is Lynn’s assessment realistic?

Forrest and Lynn must believe that courts would interpret these bills as if they meant the exact opposite of their actual text. It is the job of courts to accurately interpret laws, and it is difficult to see how a court could find that such language would permit the teaching of religion. It seems logically impossible for the teaching of religion to be protected by such a bill.

The only way that Forrest’s “creationist code language” / “stealth creationism” argument could be valid is if all teachers in the State of Louisiana were in on some massive—and obviously non-existent—conspiracy where they all believe that “objective discussion of scientific theories” (the actual language of SB 733) really means “teach religion.” Are Dr. Forrest’s arguments a sign of profound weakness in academic freedom legislation, or a sign of profound desperation on the part of critics to find counter-arguments against these bills?

Rhetoric from critics of academic freedom legislation in other states has predictably followed a similar course. In 2009, faculty at the University of Oklahoma affiliated with the group Oklahomans for Excellence in Science Education produced and distributed a document to members of the Oklahoma State legislature opposing an academic freedom bill. The critical document tried to link the Oklahoma bill to religion, stating: “This is a ‘Trojan horse’ bill intended to open the door for the teaching of religious concepts in school science classes . . . . SB320 makes the completely baseless association between academic freedom and freedom to teach religion in classes that are not about religion.”<sup>194</sup>

The actual language of the Oklahoma bill was highly similar to the Louisiana Science Education Act and offered a very different picture of the legislation. In fact, it included a statement of inextricably clear legislative intent to *not* protect the teaching of religion:

This act only protects the teaching of scientific information, and this act shall not be construed to promote any religious or non-religious doctrine, promote discrimination for or against a particular

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192. See Louisiana Science Education Act, La. Rev. Stat. Ann. § 17:285.1 (2008). The final vote in the Louisiana State House of Representatives was 93–4, and in the Louisiana State Senate, 36–0.

193. Vincent Rossemeier, Louisiana Schools Open to Creationism?, WAR ROOM (June 12, 2008), [http://www.salon.com/politics/war\\_room/2008/06/12/louisiana\\_creationism/index.html](http://www.salon.com/politics/war_room/2008/06/12/louisiana_creationism/index.html) (quoting Barry Lynn).

194. Oklahomans for Excellence in Science Education, Oppose SB 320, the “Science Education and Academic Freedom Act” 1 (on file with author).

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set of religious beliefs or non-beliefs, or promote discrimination for or against religion or non-religion. On the contrary, the intent is to create an environment in which both the teacher and students can openly and objectively discuss the facts and observations of science, and the assumptions that underlie their interpretation.<sup>195</sup>

The critical document also adopted the “lawsuit-threat” scare-tactic in full measure stating: “In Louisiana school districts have faced serious problems implementing the law and costly lawsuits filed over its constitutionality.”<sup>196</sup> But that assertion, distributed among legislators who voted on this bill, is a plain falsehood; there have been no lawsuits whatsoever filed in Louisiana over the Science Education Act. It is most distressing that legislators concerned about the problems in science education are being fed outright false information by opponents of TES policies.

The reality is that these bills only protect the teaching of scientific information, expressly do not cover the teaching of religion, and protect teaching of the scientific evidence for evolution as much as they protect the scientific evidence against. Academic freedom legislation simply asks for freedom for teachers to teach both the evidence for and against evolution and other controversial scientific theories. Critics who want the evidence for evolution taught but not the evidence against it find that their only way to respond to the legislation is by misrepresenting it as somehow permitting the teaching of religion.

These tactics to relabel scientific critique of evolution as creationism or religion are nothing new. A 1999 article from *Reports of the National Center for Science Education*, titled *A New Tactic for Getting ‘Creation Science’ Into Classrooms?*, concludes, “Don’t be surprised if some day one of these friends calls and asks, ‘My child’s teacher is talking about ‘evidence against evolution’. What can I do?’”<sup>197</sup> With references throughout alluding to the unconstitutionality of advocating creationism in public schools, it seems clear that the NCSE opposes teaching scientific critique of evolution by falsely equating it with the advocacy of creation science.<sup>198</sup>

Ironically, while opponents of TES policies constantly charge that “creationism” has been relabeled as “scientific critique of evolution,” it seems that the only party who is doing any relabeling are TES opponents themselves who constantly claim that “scientific critique of evolution” is

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195. SB 320, 52<sup>nd</sup> Leg., 1<sup>st</sup> Sess. (Okla. 2009).

196. Oklahomans for Excellence in Science Education, *supra* note 194, at 2.

197. Molleen Matsumura, *A New Tactic for Getting “Creation Science” Into Classrooms?* 19 REPORTS OF THE NATIONAL CENTER FOR SCIENCE EDUCATION, May-June 1999 at 24, 26.

198. *Id.* at 24–26. (“When they hear that their teachers are teaching ‘creation science’ in the science classroom, school district administrators or board members who understand the scientific issues - or at least the legal repercussions - will often tell them to stop, and sometimes that’s the end of the story”) (internal citations omitted).

the equivalent of advocating “creationism.”

#### *4. Asserting that There Is No Scientific Controversy Over Evolution*

Another common objection to teaching evolution critically is the assertion that there is simply no scientific controversy to teach. This argument is captured by criticisms leveled against the 2009 Oklahoma Academic Freedom bill:

Promoting the notion that there is some scientific controversy is just plain dishonest . . . . The fact that evolution has occurred is accepted by virtually all scientists around the world and is as well established as the fact that the Earth is round. There really are no scientific ‘weaknesses.’ If one looks at the sources of these alleged weaknesses, we find they are phony fabrications, invented and promoted by people who don’t like evolution.<sup>199</sup>

The effect of such assertions is to chill academic freedom through scare-tactics where teachers fear they will be subject to ridicule, intimidation, or worse if they raise these scientific controversies with students. Ironically, such attacks provide strong justification for the need for academic freedom legislation. Critics create the need for the very policy they oppose.

Eugenie Scott and Glenn Branch of the NCSE also express the sentiment that there is no controversy using somewhat more subdued language stating: “[A]lthough ‘teaching the controversy’ sounds fair, it is unfair to pretend to students that a controversy exists in science where none does.”<sup>200</sup> Stephen Meyer responds to these arguments by observing that there are core scientific questions about evolution, provided “evolution” is understood as the modern neo-Darwinian paradigm:

Scott and Branch deny the existence of any significant scientific controversies about the ‘validity of evolution’. But the credibility of their position depends on definitional equivocation. All reputable scientists agree that ‘evolution happened’, they insist. Overwhelming evidence reinforces this opinion. And, of course, they are right if they equate ‘evolution’ with ‘change over time’ or ‘descent with modification’ (as they do when pressed).

Yes, life has changed over time. But, of course, neo-[D]arwinism affirms a good deal more than that. In particular, it affirms that: (i) that an undirected processes [sic], principally natural selection acting on random mutations, is sufficient to

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199. Oklahomans for Excellence in Science Education, *supra* note 195, at 1 (emphasis omitted).

200. Eugenie C. Scott and Glenn Branch, *Evolution: What's Wrong With 'Teaching the Controversy'?* 18 TRENDS IN ECOLOGY AND EVOLUTION 499, 501 (2003).

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generate biological complexity; and (ii) all organisms have descended from a common ancestor.

Scott herself acknowledges significant scientific debate about the sufficiency of the neo-[D]arwinian mechanism. Recently, in a public forum at the University of San Francisco, she also acknowledged that many evolutionary biologists now disagree about the truth of universal common descent. Our position, radical though it might seem, is that students should be informed about such dissenting opinion and, furthermore, that they should be told why some scientists doubt aspects of neo-[D]arwinism.<sup>201</sup>

If anything, doubts about some of the core claims of neo-Darwinism have increased since Meyer wrote those words. More than 800 Ph.D. scientists have now signed a statement expressing their skepticism of modern evolutionary theory's "claims for the ability of random mutation and natural selection to account for the complexity of life," and urge that "[c]areful examination of the evidence for Darwinian theory should be encouraged."<sup>202</sup>

Numerous articles in mainstream scientific literature discuss scientific problems with core aspects of modern neo-Darwinian evolutionary theory.<sup>203</sup> An article in *Trends in Ecology and Evolution* from 2008 acknowledge that there exists a "healthy debate concerning the sufficiency of neo-Darwinian theory to explain macroevolution."<sup>204</sup> In 2009, Günter Theißen of the Department of Genetics at Friedrich Schiller University in Jena, Germany wrote in the journal *Theory in Biosciences* that modern Darwinian theory has not fully explained biological complexity:

[W]hile we already have a quite good understanding of how organisms adapt to the environment, much less is known about the mechanisms behind the origin of evolutionary novelties, a process that is arguably different from adaptation. Despite Darwin's undeniable merits, explaining how the enormous complexity and diversity of living beings on our planet originated remains one of the greatest challenges of biology.<sup>205</sup>

An even more striking criticism of what he called the "dogmatic science" of

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201. Stephen C. Meyer, *Teaching About Scientific Dissent From Neo-Darwinism*, 19 TRENDS IN ECOLOGY AND EVOLUTION 115 (Mar. 2004).

202. See A Scientific Dissent from Darwinism, Home Page, <http://www.DissentfromDarwin.org> (last visited Dec. 19, 2009).

203. For a sample listing, see Discovery Institute, BIBLIOGRAPHY OF SUPPLEMENTARY RESOURCES FOR SCIENCE INSTRUCTION (JAN. 1, 2004), <http://www.discovery.org/a/1127>.

204. Michael A. Bell, *Gould's Most Cherished Concept*, 23 TRENDS IN ECOLOGY AND EVOLUTION 121, 121–22 (2008) (reviewing STEPHEN JAY GOULD, PUNCTUATED EQUILIBRIUM (2007)).

205. Günter Theißen, *Saltational Evolution: Hopeful Monsters are Here to Stay*, 128 THEORY IN BIOSCIENCES, 43, 44 (2009) (internal citations omitted).

neo-Darwinian thinking can be found in a 2006 paper by Theißen:

Explaining exactly how the great complexity and diversity of life on earth originated is still an enormous scientific challenge . . . . There is the widespread attitude in the scientific community that, despite some problems in detail, textbook accounts on evolution have essentially solved the problem already. In my view, this is not quite correct.<sup>206</sup>

Theißen is by no means the only mainstream evolutionary biologist who has leveled core criticisms against the prevailing neo-Darwinian paradigm. U.S. National Academy of Sciences member biologist Lynn Margulis is a notorious critic of neo-Darwinism:

We agree that very few potential offspring ever survive to reproduce and that populations do change through time, and that therefore natural selection is of critical importance to the evolutionary process. But this Darwinian claim to explain all of evolution is a popular half-truth whose lack of explicative power is compensated for only by the religious ferocity of its rhetoric. Although random mutations influenced the course of evolution, their influence was mainly by loss, alteration, and refinement. One mutation confers resistance to malaria but also makes happy blood cells into the deficient oxygen carriers of sickle cell anemics. Another converts a gorgeous newborn into a cystic fibrosis patient or a victim of early onset diabetes. One mutation causes a flighty red-eyed fruit fly to fail to take wing. Never, however, did that one mutation make a wing, a fruit, a woody stem, or a claw appear. Mutations, in summary, tend to induce sickness, death, or deficiencies. No evidence in the vast literature of heredity changes shows unambiguous evidence that random mutation itself, even with geographical isolation of populations, leads to speciation.<sup>207</sup>

Evolutionary biologist Stanley Salthe likewise describes himself as “a critic of Darwinian evolutionary theory,”<sup>208</sup> which he insists “cannot explain origins, or the actual presence of forms and behaviors”<sup>209</sup> in organisms. Journalist Susan Mazur elaborates on Salthe’s criticisms of Darwinism:

Stanley Salthe, a natural philosopher at Binghamton University with a PhD in zoology—who says he can’t get published in the

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206. Theißen, *supra* note 62.

207. LYNN MARGULIS & DORION SAGAN, ACQUIRING GENOMES: A THEORY OF THE ORIGINS OF THE SPECIES 29 (2002).

208. Stanley N. Salthe, Home Page, <http://www.nbi.dk/~natphil/salthe/> (last visited Dec. 18, 2009).

209. Stanley N. Salthe, Analysis and Critique of the Concept of Natural Selection (and of the NeoDarwinian Theory of Evolution) in Respect (Part 1) to its Suitability as Part of Modernism’s Origination Myth, as Well as (Part 2) of its Ability to Explain Organic Evolution (2006), [http://www.nbi.dk/~natphil/salthe/Critique\\_of\\_Natural\\_Select\\_.pdf](http://www.nbi.dk/~natphil/salthe/Critique_of_Natural_Select_.pdf).

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mainstream media with his views . . . told me the following: “Oh sure natural selection’s been demonstrated . . . the interesting point, however, is that it has rarely if ever been demonstrated to have anything to do with evolution in the sense of long-term changes in populations . . . Summing up we can see that the import of the Darwinian theory of evolution is just unexplainable caprice from top to bottom. What evolves is just what happened to happen.”<sup>210</sup>

Mazur gained notoriety for reporting on the 2008 Altenberg 16 conference where critics of neo-Darwinism gathered in Altenberg, Austria to discuss insufficiencies of the modern synthesis of evolution. According to Mazur, there are “hundreds of other evolutionary scientists (non-creationists) who contend that natural selection is politics, not science, and that we are in a quagmire because of staggering commercial investment in a Darwinian industry built on an inadequate theory.”<sup>211</sup>

*Nature* also published an article covering the Altenberg 16 conference, quoting biologist Scott Gilbert stating that “[t]he modern synthesis is remarkably good at modeling the survival of the fittest, but not good at modeling the arrival of the fittest.”<sup>212</sup> Stuart Newman stated in the same article, “You can’t deny the force of selection in genetic evolution . . . but in my view this is stabilizing and fine-tuning forms that originate due to other processes.”<sup>213</sup> Evolutionary paleobiologist Graham Budd was similarly open in the article about deficiencies in explanations of key evolutionary transitions: “When the public thinks about evolution, they think about the origin of wings and the invasion of the land, . . . [b]ut these are things that evolutionary theory has told us little about.”<sup>214</sup>

Also in 2008, William Provine, a Cornell University historian of science and evolutionary biologist, gave a talk before the History of Science Society titled “Random Drift and the Evolutionary Synthesis.” An abstract of his talk argues “[e]very assertion of the evolutionary synthesis below is false:”

1. Natural selection was the primary mechanism at every level of the evolutionary process. Natural selection caused genetic adaptation . . . .
4. Evolution of phenotypic characters such as eyes and ears, etc, was a good guide to protein evolution: or, protein evolution was expected to mimic phenotypic evolution.
5. Protein evolution was a good guide to DNA sequence evolution. Even

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210. SUSAN MAZUR, *THE ALTENBERG 16: AN EXPOSÉ OF THE EVOLUTION INDUSTRY* 21 (North Atlantic Books 2010).

211. *Id.* at 55.

212. John Whitfield, *Biological Theory: Postmodern Evolution?*, 455 *NATURE* 281, 282 (2008) (quoting Scott Gilbert).

213. *Id.* at 283 (quoting Stewart Newman).

214. *Id.* at 282 (quoting Graham Budd).

Lewontin and Hubby thought, at first, that understanding protein evolution was the key to understanding DNA evolution. 6. Recombination was far more important than mutation in evolution. 7. Macroevolution was a simple extension of microevolution. 8. Definition of “species” was clear[—]the biological species concept of Dobzhansky and Mayr. 9. Speciation was understood in principle. 10. Evolution is a process of sharing common ancestors back to the origin of life, or in other words, evolution produces a tree of life. 11. Inheritance of acquired characters was impossible in biological organisms. 12. Random genetic drift was a clear concept and invoked constantly whenever population sizes were small, including fossil organisms. 13. The evolutionary synthesis was actually a synthesis.<sup>215</sup>

Not long before this article went to publication, Eugene V. Koonin of the National Center for Biotechnology Information stated in *Trends in Genetics* that due to breakdowns in core neo-Darwinian tenets such the “traditional concept of the tree of life” or the view that “natural selection is the main driving force of evolution” indicate that “the modern synthesis has crumbled, apparently, beyond repair” and “all major tenets of the modern synthesis have been, if not outright overturned, replaced by a new and incomparably more complex vision of the key aspects of evolution.”<sup>216</sup> Koonin concludes, “not to mince words, the modern synthesis is gone.”<sup>217</sup>

Most biology textbooks today present the standard neo-Darwinian paradigm as if it is unadulterated fact. But the core claims of the modern synthesis are being called into question. If students can learn about the scientific evidence for neo-Darwinian evolution, then there is no reason why they could not learn about the scientific evidence countering core aspects of modern evolutionary theory. Such scientific debates over key aspects of Darwin’s theory are not inappropriate to include in public school biology curricula.

At the very least, such noteworthy acknowledgment from mainstream scientific sources about core weaknesses in the prevailing neo-Darwinian paradigm make it difficult to take seriously Nicholas Matzke’s contention that criticisms of neo-Darwinism are merely “traceable to primary texts of the intelligent design (ID) and creation science (CS) movements” and “are, without exception, aimed at promoting the sectarian doctrine of special creation.”<sup>218</sup> Matzke’s argument appears designed to shut down scientific

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215. William Provine, Random Drift and the Evolutionary Synthesis, History of Science Society HSS Abstracts, <http://www.hssonline.org/meeting/oldmeetings/archiveprogs/2008archiveMeeting/2008HSSAbstracts.html> (last visited Dec. 18, 2009).

216. Eugene V. Koonin, *The Origin at 150: Is a New Evolutionary Synthesis in Sight?*, 25 TRENDS IN GENETICS 473, 473–74 (2009) (internal citations omitted).

217. *Id.* at 474.

218. Matzke & Gross, *supra* note 164, at 29.

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debate over neo-Darwinism and to prevent students from critically investigating the modern theory of evolution.

This article is not by any means intended to be an exhaustive review of scientific controversies over neo-Darwinism. However, the next section will cover a few examples of scientific debates about neo-Darwinian evolution to demonstrate that there is legitimate science that challenges the dumbed-down version of evolution-education recommended by evolution lobbyists.

#### **IV. THERE IS LEGITIMATE SCIENCE THAT CHALLENGES DUMBED-DOWN EVOLUTION EDUCATION**

In 2005, the NSTA issued its *Science Curriculum Topic Study* as a “comprehensive and detailed guide for using [the National Science Education Standards] as the starting point to improve the quality of a wide range of science education activities for multiple audiences.”<sup>219</sup> The intent of the Curriculum Topic Study (CTS) was to provide teachers with an understanding of the “supporting documents” for NSES, published in 1996 by the National Research Council, upon which many state science standards are based.<sup>220</sup> The book provided the following guidance:

CTS is designed to help teachers identify the content they need to understand in order to teach ideas at a level appropriate for their students. Two resources used in CTS for the purpose of improving teachers’ content knowledge are *Science for all Americans* (AAAS, 1990) and *Science Matters* (Hazen & Trefil, 1991). The former describes the specific ideas and skills that a scientifically literate adult should have.<sup>221</sup>

One of the NSTA’s primary recommended sources, Hazen & Trefil’s book, *Science Matters: Achieving Scientific Literacy*, indeed discusses many scientific ideas apparently necessary for scientific literacy. As one example, they promote the long-discarded notion that the earth’s early atmosphere was rich in methane and ammonia and thus was accurately simulated in the Miller-Urey experiments of the 1950s that produced amino acids:

The gases that came from volcanoes to form the first atmosphere were primary ammonia (NH<sub>3</sub>), methane (CH<sub>4</sub>), carbon dioxide (CO<sub>2</sub>), hydrogen (H<sub>2</sub>), and water (H<sub>2</sub>O). . . . In 1953 Stanley Miller and Harold Urey at the University of Chicago designed an experiment to find out what natural process might have formed the

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219. Harold Pratt, *Foreward* to PAGE KEELEY, *SCIENCE CURRICULUM TOPIC STUDY: BRIDGING THE GAP BETWEEN STANDARDS AND PRACTICE*, xi (2005).

220. *Id.*

221. PAGE KEELEY, *SCIENCE CURRICULUM TOPIC STUDY: BRIDGING THE GAP BETWEEN STANDARDS AND PRACTICE* 15 (2005).

complex molecules necessary for life.

Miller and Urey tried to reproduce the early earth's environment in a jar. Into the glassware they poured water and created an atmosphere of ammonia, methane, water, and hydrogen gases. They continually heated and mixed the gases and water while electric sparks, simulating lightning, added energy. The results were amazing. . . . chemical analysis revealed amino acids—the building blocks of proteins.

. . . .

. . . This research demonstrates that there is no problem making extremely complex molecules in conditions like those in the atmosphere or oceans of the primitive earth.<sup>222</sup>

Of course it is now known—and it was known at the time Hazen and Trefil published their book in 1990—that the Earth's early atmosphere was not composed of methane or ammonia and would not have been conducive to Miller-Urey type chemistry.<sup>223</sup> As origin of life theorist David Deamer explains, “This optimistic picture began to change in the late 1970s, when it became increasingly clear that the early atmosphere was probably volcanic in origin and composition, composed largely of carbon dioxide and nitrogen rather than the mixture of reducing gases assumed by the Miller-Urey model. Carbon dioxide does not support the rich array of synthetic pathways leading to possible monomers . . . .”<sup>224</sup>

The NSTA's recommendation and citation of Hazen and Trefil's inaccurate book as a source document for improving scientific literacy is part of a much larger trend which, when implemented, promotes overly simplistic accounts of chemical and biological evolution to students, glossing over inaccuracies or contrary data in order to present a neat and tidy but false picture of evolution. It embodies what one Biology 101 lecturer at Wesleyan College had in mind when in 2008 he endorsed teaching students “inaccuracies” that are “wrong” if that enables educators to “gain their trust” and “help them accept evolution.”<sup>225</sup>

Unfortunately such an attitude seems prevalent among certain evolution lobbyists, underscoring the need for scientific accuracy when teaching evolution, which only a true implementation of the inquiry method can

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222. ROBERT M. HAZEN & JAMES TREFIL, *SCIENCE MATTERS: ACHIEVING SCIENTIFIC LITERACY* 245–46 (Doubleday 1991).

223. See Adam P. Johnson, et al., *The Miller Volcanic Spark Discharge Experiment*, 322 *SCIENCE* 404 (2008); D.W. Deamer, *The First Living Systems: a Bioenergetic Perspective*, 61 *MICROBIOLOGY & MOLECULAR BIOLOGY REVIEWS* 239 (1997).

224. Deamer, *supra* note 223, at 244. (internal citations omitted).

225. For details, see Discovery Institute, *Lying in the Name of Indoctrination*, [http://www.evolutionnews.org/2008/08/lying\\_in\\_the\\_name\\_of\\_indoctrin.html](http://www.evolutionnews.org/2008/08/lying_in_the_name_of_indoctrin.html) (last visited Dec. 18, 2009).

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provide. Yet even when state boards of education require true critical analysis when teaching evolution, textbook publishers rebel.

Soon after the Texas State Board of Education (TSBOE) voted to adopt TEKS, which requires students to “analyze and evaluate” core aspects of neo-Darwinism, Josh Rosenau of the NCSE approvingly reported that some textbook publishers pledged to “abide by the letter, but not the spirit” of the new Texas law.<sup>226</sup> One of those textbook publishers was Rene LeBel of J.M. Lebel publishers, which had submitted a biology textbook for consideration by the TSBOE in 2003.<sup>227</sup> The Lebel textbook’s approach to teaching evolution was illustrative of the dumbed-down version of evolution education commonly promoted by the evolution lobby. One review found that Lebel’s textbook committed some of the same mistakes as Hazen & Trefil regarding the Miller-Urey experiment, noting that the “text falsely implies that when ‘common volcanic gases like carbon dioxide (CO<sub>2</sub>), carbon monoxide (CO), [and] molecular nitrogen (N<sub>2</sub>)’ are used, the experiment still works.”<sup>228</sup> The textbook contained additional problems, indicative of the type of error-tolerant and oversimplified evolution instruction likely to be seen when Lebel submits textbooks for adoption in Texas in 2011.<sup>229</sup>

Four additional case studies will be offered below where evolution lobbyists have sought to dumb-down evolution education by advocating the teaching of simplistic, disputed, or downright inaccurate versions of evolutionary biology to students. If their recommendations for evolution education were adopted, this would work directly against the benefits that educators seek to gain from employing the inquiry method of teaching science during evolution instruction.

#### A. THE 2009 TEXAS EVOLUTION HEARINGS<sup>230</sup>

In January 2009, the TSBOE held hearings on whether to teach both the scientific “strengths and weaknesses” of modern evolutionary biology. During those hearings, the TSBOE invited six experts to offer advisory

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226. Josh Rosenau, *Don't Mess with Textbooks*, SEED MAGAZINE, May 20, 2009, [http://seedmagazine.com/content/print/dont\\_mess\\_with\\_textbooks/](http://seedmagazine.com/content/print/dont_mess_with_textbooks/).

227. That textbook was JOSEPH RAVER, *BIOLOGY: PATTERNS AND PROCESSES OF LIFE* (2004).

228. DISCOVERY INST., *A PRELIMINARY ANALYSIS OF THE TREATMENT OF EVOLUTION IN BIOLOGY TEXTBOOKS CURRENTLY BEING CONSIDERED FOR ADOPTION BY THE TEXAS STATE BOARD OF EDUCATION 23* (2003), available at <http://www.discovery.org/articleFiles/PDFs/TexasPrelim.pdf>.

229. *See Id.* at 23–24.

230. Portions of this section are adapted from Discovery Institute, *An Analysis of the Expert Testimony of Prof. Ronald Wetherington before the Texas State Board of Education on January 21, 2009* (Mar. 27, 2009), <http://www.discovery.org/a/9961> and Discovery Institute, *An Analysis of the Expert Testimony of Prof. David Hillis before the Texas State Board of Education on January 21, 2009* (Mar. 27, 2009), <http://www.discovery.org/a/9941>.

testimony on proper evolution education policy. Three of the experts, including University of Wisconsin-Superior biology professor Ralph Seelke and Baylor University biochemist Charles Garner, testified that scientific weaknesses in evolution should be taught. The remaining three experts, including University of Texas at Austin biologist David Hillis and Southern Methodist University (SMU) anthropologist Ronald Wetherington, testified that there are no legitimate “weaknesses” in neo-Darwinian evolution that should be presented to students.<sup>231</sup>

During his testimony to the board, Professor Hillis described himself as one of the “world’s leading” experts on the “tree of life.”<sup>232</sup> He stated that when constructing evolutionary trees using biomolecules, there is an “overwhelming agreement [and] correspondence as you go from protein to protein, DNA sequence to DNA sequence.”<sup>233</sup> His conclusion was that there are no scientific weaknesses in evolution that should be taught to students.<sup>234</sup> Yet the very day Hillis testified, the journal *New Scientist* published a cover story titled, *Why Darwin Was Wrong About the Tree of Life*, reporting about frequent conflicts and incongruities between evolutionary trees. The article’s candidness was striking:

“For a long time the holy grail was to build a tree of life,” says Eric Baptiste, an evolutionary biologist at the Pierre and Marie Curie University in Paris, France. A few years ago it looked as though the grail was within reach. But today the project lies in tatters, torn to pieces by an onslaught of negative evidence. Many biologists now argue that the tree concept is obsolete and needs to be discarded. “We have no evidence at all that the tree of life is a reality,” says Baptiste. That bombshell has even persuaded some that our fundamental view of biology needs to change.<sup>235</sup>

According to the article, the basic problem is that one DNA sequence would yield one tree, while another sequence would yield a different tree:

The problems began in the early 1990s when it became possible to sequence actual bacterial and archaeal genes rather than just RNA. Everybody expected these DNA sequences to confirm the RNA tree, and sometimes they did but, crucially, sometimes they did not. RNA, for example, might suggest that species A was more closely related to species B than species C, but a tree made from

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231. Discovery Institute, *An Analysis of the Expert Testimony of Prof. David Hillis before the Texas State Board of Education on January 21, 2009* (Mar. 27, 2009), <http://www.discovery.org/a/9941>.

232. *Id.*

233. *Id.*

234. *Id.*

235. Graham Lawton, *Why Darwin Was Wrong About the Tree of Life*, *NEW SCIENTIST*, Jan. 21, 2009, <http://www.newscientist.com/article/mg20126921.600-why-darwin-was-wrong-about-the-tree-of-life.html?full=true>.

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DNA would suggest the reverse.”<sup>236</sup>

The article discusses various proposals among evolutionary scientists to resolve these incongruities, largely entailing *ad hoc* appeals to a process called lateral gene transfer (LGT), where bacteria swap genes, thereby muddying any phylogenetic signal.<sup>237</sup> Hillis had claimed that biologists find “overwhelming agreement [and] correspondence as you go from protein to protein, DNA sequence to DNA sequence.”<sup>238</sup> Contrary to Hillis, this review article stated precisely the opposite, observing that “the evolution of animals and plants isn’t exactly tree-like either” and that even among higher branches of the tree of life (where LGT is not thought to be prevalent), “[t]he problem was that different genes told contradictory evolutionary stories.”<sup>239</sup> This led one scientist to admit that even among these relationships of higher organisms “[w]e’ve just annihilated the tree of life.”<sup>240</sup>

In 2005, Kansas adopted a standard suggesting that students learn about “[d]iscrepancies in the molecular evidence (e.g., differences in relatedness inferred from sequence studies of different proteins) previously thought to support” common ancestry.<sup>241</sup> Opposing such a standard, former NCSE staff member Nicholas Matzke wrote:

The claim is that phylogenetic trees based on different data sets conflict so badly as to call common ancestry into question. The usual creationist procedure is to dig through the scientific literature to find cases where studies disagree on the exact phylogenetic relationships of organisms and then to trumpet these as inexplicable discrepancies that refute common ancestry.<sup>242</sup>

Of course, statements that “[w]e’ve just annihilated the tree of life” seem a little more injurious to the tree of life hypothesis than mining for the occasional studies that “disagree on the exact phylogenetic relationships of organisms.” Matzke’s view promotes a form of evolution education that papers over severe deficiencies in neo-Darwinian evolution. Moreover, it

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236. *Id.*

237. *Id.* Lateral gene transfer (LGT) is an after-the-fact explanation commonly invoked to explain away incongruent phylogenetic data. See Mark A. Ragan and Robert G. Beiko, *Lateral Genetic Transfer: Open Issues*, 364 PHIL.TRANS.R.SOC. B 2241-51 (2009) (“In the phylogenetic approach, each instance of topological discordance between a gene tree and a trusted reference tree is taken as a *prima facie* instance of LGT. Discordance can be found throughout the entire range of nodal depths within these trees, from recent (genera, species) to older, presumably reflecting a commerce in genetic material that has been ongoing since pre-genomic times (Woese 2000). Viewed in this way, every genome has LGT in its ancestry”).

238. Discovery Institute, *supra* note 231.

239. Lawton, *supra* note 235.

240. *Id.* (quoting Michael Syvanen).

241. KAN. DEP’T. OF EDUC., 2005 KANSAS SCIENCE STANDARDS, Standard 3: Life Science Grades 8–12, (1)(f)(i) (2005).

242. Matzke & Gross, *supra* note 164, at 36.

seems evident that fundamental criticisms to the tree of life hypothesis are coming from non-creationist sources that do not promote “the sectarian doctrine of special creation.”<sup>243</sup>

Later in his testimony, Hillis further argued that “there’s overwhelming correspondence between the basic structures we have about the tree of life from anatomical data, from biochemical data, molecular sequence data.”<sup>244</sup> Likewise, Matzke asserts that “phylogenies derived independently from morphological (anatomical) and molecular (chemical) data sets typically show a high degree of correlation.”<sup>245</sup> The views of Hillis and Matzke, however, are countered by a number of credible scientific authorities.

The prevalence of disagreement and non-correspondence between molecule-based evolutionary trees and anatomy-based evolutionary trees led to a major article in *Nature* that reported that “disparities between molecular and morphological trees” lead to “evolution wars” because “[e]volutionary trees constructed by studying biological molecules often don’t resemble those drawn up from morphology.”<sup>246</sup> The article’s revelation of the disparities between molecular and morphological phylogenies was striking:

When biologists talk of the ‘evolution wars,’ they usually mean the ongoing battle for supremacy in American schoolrooms between Darwinists and their creationist opponents. But the phrase could also be applied to a debate that is raging within systematics. On one side stand traditionalists who have built evolutionary trees from decades of work on species’ morphological characteristics. On the other lie molecular systematists, who are convinced that comparisons of DNA and other biological molecules are the best way to unravel the secrets of evolutionary history.

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So can the disparities between molecular and morphological trees ever be resolved? Some proponents of the molecular approach claim there is no need. The solution, they say, is to throw out morphology, and accept their version of the truth. “Our method provides the final conclusion about phylogeny,” claims Okada. Shared ancestry means a genetic relationship, the molecular camp argues, so it must be better to analyse DNA and the proteins it encodes, rather than morphological characters that can end up

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243. *Id.* at 29.

244. Discovery Institute, Texas Hold ‘Em Part II: Calling David Hillis’ Bluffs about the Tree of Life in His January Texas State Board of Education Testimony, [http://www.evolutionnews.org/2009/04/texas\\_hold\\_em\\_part\\_ii\\_calling.html](http://www.evolutionnews.org/2009/04/texas_hold_em_part_ii_calling.html) (last visited Jan. 24, 2010) (quoting David Hillis).

245. Matzke & Gross, *supra* note 164, at 36.

246. Trisha Gura, *Bones, Molecules or Both?*, 406 NATURE 230, 230 (2000).

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looking similar as a result of convergent evolution in unrelated groups, rather than through common descent. But morphologists respond that convergence can also happen at the molecular level, and note there is a long history of systematists making large claims based on one new form of evidence, only to be proved wrong at a later date.<sup>247</sup>

Likewise, a review article in the journal *Bioessays* reported that despite a vast increase in the amount of data since Darwin's time, "our ability to reconstruct accurately the tree of life may not have improved significantly over the last 100 years,"<sup>248</sup> and that, "[d]espite increasing methodological sophistication, phylogenies derived from morphology, and those inferred from molecules, are not always converging on a consensus."<sup>249</sup> Strikingly, an article in *Trends in Ecology and Evolution* concluded that "the wealth of competing morphological, as well as molecular proposals . . . of [the] prevailing phylogenies of the mammalian orders would reduce [the mammalian tree] to an unresolved bush, the only consistent clade probably being the grouping of elephants and sea cows."<sup>250</sup>

Unfortunately, the views of Matzke and Hillis make their way into textbooks, blurring out deficiencies in modern neo-Darwinian evolution and preventing students from investigating cutting edge debates among evolutionary biologists. For example, textbooks often tout the cytochrome C phylogenetic tree as allegedly corroborating and confirming the traditional phylogeny of many animal groups.<sup>251</sup> But such textbooks ignore the cytochrome B tree, which has *striking differences* from the classical animal phylogeny. As one article in *Trends in Ecology and Evolution* stated: "[T]he mitochondrial cytochrome b gene implied . . . an absurd phylogeny of mammals, regardless of the method of tree construction. Cats and whales fell within primates, grouping with simians (monkeys and apes) and strepsirhines (lemurs, bush-babies and lorises) to the exclusion of tarsiers. Cytochrome b is probably the most commonly sequenced gene in vertebrates, making this surprising result even more disconcerting."<sup>252</sup> While Matzke and Hillis are certainly entitled their opinions, promoting

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247. *Id.* at 230–32.

248. Matthew A. Wills, *The Tree of Life and the Rock of Ages: Are We Getting Better at Estimating Phylogeny*, 24 *BIOESSAYS* 203, 203(2002) (emphasis omitted) (reporting on the findings of Michael J. Benton, *Finding the Tree of Life: Matching Phylogenetic Trees to the Fossil Record Through the 20th Century*, 268 *PROCEEDINGS OF THE ROYAL SOCIETY OF LONDON B* 2123–30 (2001)).

249. *Id.* at 206.

250. Wilfried. W. De Jong, *Molecules Remodel the Mammalian Tree*, 13 *TRENDS IN ECOLOGY AND EVOLUTION* 270, 271 (1998).

251. See COLLEEN BELK & VIRGINIA MAIER, *BIOLOGY SCIENCE FOR LIFE WITH PHYSIOLOGY* (3d ed. 2010).

252. Michael S. Y. Lee, *Molecular Phylogenies Become Functional*, 14 *TRENDS IN ECOLOGY AND EVOLUTION* 177, 177 (1999).

them to students without mention of dissenting views would obscure actual debates among evolutionary scientists about organismal relationships and the best methods for constructing phylogenetic trees.

After Hillis, SMU anthropologist Ronald Wetherington told the TSBOE that there were no “weaknesses” in neo-Darwinism that should be taught to students. Moreover, Wetherington testified that the fossil record of human evolution has “[n]o gaps. No lack of transitional fossils. . . . So when people talk about the lack of transitional fossils or gaps in the fossil record, it absolutely is not true.”<sup>253</sup>

Again, leading authorities would disagree. In his 2004 book *What Makes Biology Unique?*, the late evolutionary biology authority Ernst Mayr acknowledged that “[t]he earliest fossils of *Homo*, *Homo rudolfensis* and *Homo erectus*, are separated from *Australopithecus* by a large, unbridged gap” where the field is in a position of “[n]ot having any fossils that can serve as missing links” between our genus *Homo* and our alleged ancestors, the australopithecine apes.<sup>254</sup> The following year, two paleoanthropologists noted in *Nature* that the earliest fossil members of *Homo* have been described as “without an ancestor, without a clear past.”<sup>255</sup> Likewise, an article in the *Journal of Human Evolution* concluded that the origin of *Homo* required “a genetic revolution” since “no australopithecine species is obviously transitional.”<sup>256</sup> One commentator said this shows a “big bang theory” of human origins, because “the first members of early *Homo sapiens* are really quite distinct from their australopithecine predecessors and contemporaries.”<sup>257</sup>

Wetherington attempted to further impress the TSBOE with the soundness of prevailing theories of human evolution by claiming that “[e]very fossil we find reinforces the sequence that we had previously supposed to exist rather than suggesting something different.”<sup>258</sup> Yet, one of the very first fossils that Wetherington touted as “transitional”—the Toumai skull—refutes his claim. When Toumai was first reported in 2002, paleoanthropologists were presented with a dilemma: The skull was far too

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253. Discovery Institute, Texas Hold 'Em Part III: Calling Ronald Wetherington's Bluffs about Human Evolution in His January Texas State Board of Education Testimony, [http://www.evolutionnews.org/2009/04/texas\\_hold\\_em\\_part\\_ii\\_calling\\_1.html](http://www.evolutionnews.org/2009/04/texas_hold_em_part_ii_calling_1.html) (last visited Jan. 24, 2010).

254. ERNST MAYR, *WHAT MAKES BIOLOGY UNIQUE?: CONSIDERATIONS ON THE AUTONOMY OF A SCIENTIFIC DISCIPLINE* 198 (2004).

255. Robin Dennell & Wil Roebroeks, *An Asian Perspective on Early Human Dispersal From Africa*, 438 *NATURE* 1099, 1099 (2005) (internal citations omitted).

256. John Hawks et al., *Population Bottlenecks and Pleistocene Evolution*, 17 *J. OF MOLECULAR BIOLOGY AND EVOLUTION* 2, 4 (2000).

257. University of Michigan News Service, *New Study Suggests Big Bang Theory of Human Evolution* (January 10, 2000), <http://www.umich.edu/~newsinfo/Releases/2000/Jan00/r011000b.html>.

258. Discovery Institute, *supra* note 253.

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old for its modern appearance. But if evolutionary paleoanthropologists accepted it as a direct ancestor of humans, many subsequent human ancestors would have to be thrown out of our direct family lineage. Authority Bernard Wood lamented in *Nature*, that if we place Toumai “at the base, or stem, of the modern human clade,” then the fossil “plays havoc with the tidy model of human origins.”<sup>259</sup> Wood even observed that Toumai shows how “a single fossil can fundamentally change the way we reconstruct the tree of life.”<sup>260</sup> Contrary to Wetherington’s testimony, this was most definitely not a fossil that “reinforces the sequence that we had previously supposed to exist.”

Hillis, Wetherington, and Matzke are certainly entitled to their opinions, which in many respects reflect the oversimplified presentations of evolutionary thinking in biology textbooks. But other experts are entitled to disagree. The question now becomes, *what should be taught to students?* Should they only learn overly simplified versions of neo-Darwinian theory, along with the claim that there are no “weaknesses” in modern evolutionary biology? Or should students be taught that scientists often disagree about core evolutionary claims, and then consider credible scientific viewpoints that dissent from the neat, tidy, and often disputed presentation of evolution taught in most textbooks?

#### B. THOSE PESKY EMBRYO DRAWINGS

In August 2008, *The New York Times* reprinted material from the NCSE claiming that the 19th century embryologist Ernst Haeckel’s “long-discredited drawings” of vertebrate embryos have not been used in textbooks since “20 years ago.”<sup>261</sup> That Haeckel’s drawings were fraudulent and have been used in textbooks is essentially beyond dispute,<sup>262</sup> but the reality is that multiple biology textbooks have been used within the past 20 years that still Haeckel’s drawings to promote evolution.<sup>263</sup>

In a 2000 article in *Natural History*, Stephen Jay Gould recognized that Haeckel’s drawings not only fraudulently obscured the differences between the early stages of vertebrate embryos, but that they were used inappropriately in textbooks:

Haeckel had exaggerated the similarities by idealizations and

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259. Bernard Wood, *Palaeoanthropology: Hominid revelations From Chad*, 418 NATURE 133, 134 (2002), available at <http://www.nature.com/nature/journal/v418/n6894/pdf/418133a.pdf>.

260. *Id.* at 133.

261. *10 Questions, and Answers, about Evolution*, NEW YORK TIMES, August 23, 2008, <http://www.nytimes.com/2008/08/24/us/WEB-tenquestions.html>.

262. Even Matzke and Gross recognize that “Haeckel did exaggerate similarities in very early embryos of different species, and his figures, or derivatives of them, have appeared in a few textbooks.” Matzke & Gross, *supra* note 164, at 40.

263. See Casey Luskin, *What Do Modern Textbooks Really Say About Haeckel's Embryos?* (Mar. 27, 2007), <http://www.discovery.org/a/3935> (citing several examples).

omissions. He also, in some cases—in a procedure that can only be called fraudulent—simply copied the same figure over and over again. At certain stages in early development, vertebrate embryos do look more alike, at least in gross anatomical features easily observed with the human eye, than do the adult tortoises, chickens, cows, and humans that will develop from them. But these early embryos also differ far more substantially, one from the other, than Haeckel's figures show. Moreover, Haeckel's drawings never fooled expert embryologists, who recognized his fudgings right from the start.

At this point, a relatively straightforward factual story, blessed with a simple moral story as well, becomes considerably more complex, given the foils and practices of the oddest primate of all. Haeckel's drawings, despite their noted inaccuracies, entered into the most impenetrable and permanent of all quasi-scientific literatures: standard student textbooks of biology. . . .

. . . .

We should therefore not be surprised that Haeckel's drawings entered nineteenth-century textbooks. But we do, I think, have the right to be both astonished and ashamed by the century of mindless recycling that has led to the persistence of these drawings in a large number, if not a majority, of modern textbooks!<sup>264</sup>

Gould also quotes embryologist Michael K. Richardson, acknowledging the widespread use of Haeckel's drawings in textbooks:

If so many historians knew about the old controversy [over Haeckel's falsified drawings], then why did they not communicate this information to numerous contemporary authors who use the Haeckel drawings in their books? I know of at least fifty recent biology textbooks which use the drawings uncritically. I think this is the most important question to come out of the whole story.<sup>265</sup>

Likewise, in an article titled *Haeckel's Embryos: Fraud Rediscovered*, the journal *Science* recognized that “[g]enerations of biology students may have been misled by a famous set of drawings of embryos published 123 years ago by the German biologist Ernst Haeckel. They show vertebrate embryos of different animals passing through identical stages of development. But the impression they give, that the embryos are exactly alike, is wrong.”<sup>266</sup> The article quotes Richardson by stating that “[i]t looks like it's turning out

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264. Stephen Jay Gould, *Abscheulich!(Atrocious!)*, NATURAL HISTORY, Mar. 2000, at 42, 44–45.

265. *Id.* at 45.

266. Elizabeth Pennisi, *Haeckel's Embryos: Fraud Rediscovered*, 277 SCIENCE 1435, 1435 (1997).

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to be one of the most famous fakes in biology.”<sup>267</sup>

Elsewhere, in the journal *Anatomy and Embryology*, Richardson and other embryologists acknowledge that Haeckel’s fraud has had a non-trivial influence on both evolutionary thought and evolution education:

Haeckel’s ideas soon came in for strong criticism. His drawings are also highly inaccurate, exaggerating the similarities among embryos, while failing to show the differences (Sedgwick 1894; Richardson 1995; Raff 1996). Sedgwick (1894) argued that even closely related species of vertebrates can be told apart at all stages of development, but that the distinguishing characters are not necessarily the same as those used to distinguish among adults. . . .

. . . .

Another point to emerge from this study is the considerable inaccuracy of Haeckel’s famous figures. These drawings are still widely reproduced in textbooks and review articles, and continue to exert a significant influence on the development of ideas in this field.<sup>268</sup>

Haeckel’s long-discredited recapitulation theory is not necessarily the bedrock of evolutionary thinking today, yet his drawings still persist in textbooks as allegedly illustrating a high degree of similarity between embryos at the earliest stages of vertebrate embryonic development. Many textbooks cite such similarities in the earliest stages of vertebrate embryos as evidence for common ancestry. For example, Miller and Levine’s *Biology* states that “[i]n their early stages of development, chickens, turtles, and rats look similar, providing evidence that they shared a common ancestry.”<sup>269</sup> Likewise Belk and Borden’s *Biology: Science for Life* asserts in a caption to vertebrate embryo pictures that “Similarity among chordate embryos. Vertebrate embryos are very similar in the first stage of their development, shown here in the top row, evidence that they share a common ancestor that developed along the same pathway.”<sup>270</sup>

These particular texts commendably do not use Haeckel’s drawings, but instead use photographs of embryos. However, there *are* textbooks in use today, such as Mader’s 2010 edition of *Biology*, which continue to use Haeckel’s drawings (in Mader’s case, essentially a colorized and slightly altered version of Haeckel’s drawings) and state, “At these comparable developmental stages, vertebrate embryos have many features in common,

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267. *Id.*

268. Michael K. Richardson et al., *There is No Highly Conserved Embryonic Stage in the Vertebrates: Implications for Current Theories of Evolution and Development*, 196 *ANATOMY AND EMBRYOLOGY*, 91, 92–104 (1997) (internal citations omitted).

269. KENNETH R. MILLER & JOSEPH LEVINE, *BIOLOGY* 385 (2008).

270. See COLLEEN BELK & VIRGINIA BORDEN, *BIOLOGY: SCIENCE FOR LIFE* 240 (2d. ed. 2007).

which suggests they evolved from a common ancestor.”<sup>271</sup> Indeed, the aforementioned textbook submitted by J.M. Lebel publishing for adoption in Texas in 2003 stated, “All vertebrate embryos closely resemble one another in early development” and used a slightly simplified version of Haeckel’s original fraudulent drawings.<sup>272</sup> Thus, Haeckel’s embryo drawings are still used to illustrate a valid point, namely that vertebrate embryos share early developmental pathways, and this provides evidence for their shared ancestry.

However, some leading embryologists argue that the earliest stages of vertebrate embryo development are very different, and embryos start developing very differently, temporarily converge at a conserved stage midway through development, and then diverge again. Appearances during this conserved stage—called the “tailbud,” “phylotypic,” or “pharyngular” stage—are cherry-picked in textbooks to show similarities between vertebrates, even though the embryos are actually *more divergent at earlier stages*. As one paper in the journal *Systematic Biology* explains:

Recent workers have shown that early development can vary quite extensively, even within closely related species, such as sea urchins, amphibians, and vertebrates in general. By early development, I refer to those stages from fertilization through neurulation (gastrulation for such taxa as sea urchins, which do not undergo neurulation). Elinson (1987) has shown how such early stages as initial cleavages and gastrula can vary quite extensively across vertebrates.<sup>273</sup>

Likewise, Richardson and other embryologists explain that vertebrate embryos start off development quite different and become similar only at a middle stage of development:

According to recent models, not only is the putative conserved stage followed by divergence, but it is preceded by variation at earlier stages, including gastrulation and neurulation. This is seen for example in squamata, where variations in patterns of gastrulation and neurulation may be followed by a rather similar somite stage. Thus the relationship between evolution and development has come to be modelled as an “evolutionary hourglass.”<sup>274</sup>

The “hourglass” model of development is illustrated below, where it shows that vertebrate embryos are actually quite different in their earliest

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271. SYLVIA S. MADER, *BIOLOGY* 278 (10<sup>th</sup> ed. 2010).

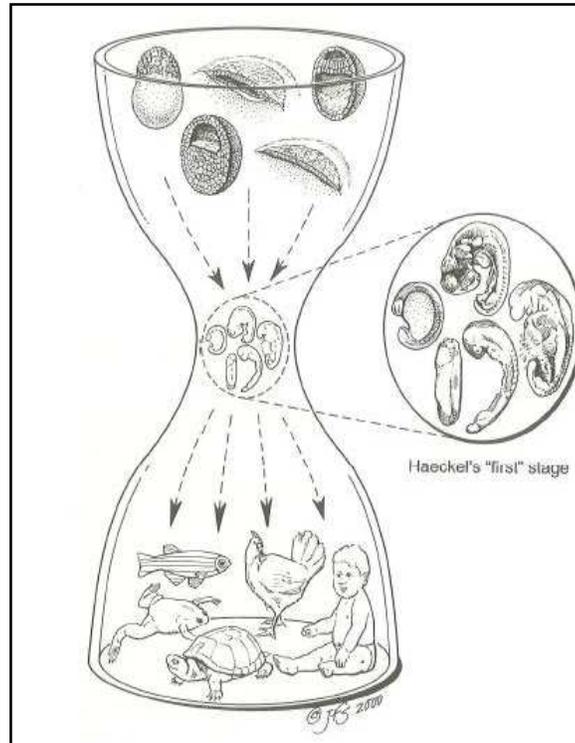
272. See DISCOVERY INST., *supra* note 228, at 23.

273. Andres Collazo, *Developmental Variation, Homology, and the Pharyngula Stage*, 49 *SYSTEMATIC BIOLOGY* 3, 9 (2000) (internal citations omitted).

274. Richardson et al., *supra* note 268, at 92 (internal citations omitted).

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stages of development:<sup>275</sup>



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Textbooks thus typically cherry pick the encircled stage as the alleged “earliest stage” of vertebrate development, when in fact vertebrates embryos at their earliest stages have significant non-trivial differences. Indeed, Richardson and other leading embryologists have called into question the very existence of a conserved “phylotopic” (or “pharyngular” or “tailbud”) stage commonly portrayed in textbooks as evidence for evolution. In a paper titled, *There is No Highly Conserved Embryonic Stage in the Vertebrates: Implications for Current Theories of Evolution and Development*, Richardson *et al.* writes the following:

We find that embryos at the tailbud stage – thought to correspond to a conserved stage – show variations in form due to allometry, heterochrony, and differences in body plan and somite number. These variations foreshadow important differences in adult body

275. The Embryonic Hourglass as published in JONATHAN WELLS, *ICONS OF EVOLUTION: WHY MUCH OF WHAT WE TEACH ABOUT EVOLUTION IS WRONG* 100 (2002). Diagram Copyright 2000 by Jody Sjogren.

form. Contrary to recent claims that all vertebrate embryos pass through a stage when they are the same size, we find a greater than 10-fold variation in greatest length at the tailbud stage. Our survey seriously undermines the credibility of Haeckel's drawings, which depict not a conserved stage for vertebrates, but a stylised amniote embryo. In fact, the taxonomic level of greatest resemblance among vertebrate embryos is below the subphylum. The wide variation in morphology among vertebrate embryos is difficult to reconcile with the idea of a phylogenetically-conserved tailbud stage, and suggests that at least some developmental mechanisms are not highly constrained by the zootype. . . .

. . . .

Contrary to the evolutionary hourglass model, variations in the adult body plan are often foreshadowed by modifications of early development. A good example is the aortic arch system in the rat that, even during the pharyngula stage, begins to presage the adult pattern of arteries. Thus the first arch has already broken down completely by the 25-somite stage in the rat (de Ruiter et al. 1989).

In summary, evolution has produced a number of changes in the embryonic stages of vertebrates including:

1. Differences in body size
2. Differences in body plan (for example, the presence or absence of paired limb buds)
3. Changes in the number of units in repeating series such as the somites and pharyngeal arches
4. Changes in the pattern of growth of different fields (allometry)
5. Changes in the timing of development of different fields (heterochrony)

These modifications of embryonic development are difficult to reconcile with the idea that most or all vertebrate clades pass through an embryonic stage that is highly resistant to evolutionary change. This idea is implicit in Haeckel's drawings, which have been used to substantiate two distinct claims. First, that differences between species typically become more apparent at late stages. Second, that vertebrate embryos are virtually identical at earlier stages. This first claim is clearly true. Our survey, however, does not support the second claim, and instead reveals considerable variability – and evolutionary lability – of the tailbud stage, the purported phylotypic stage of vertebrates.<sup>276</sup>

Former NCSE staff member Matzke co-writes that complaints about the use

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276. Richardson, *supra* note 268, at 91, 105.

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of Haeckel's drawings is a "manufactured scandal."<sup>277</sup> Not only are textbooks using inaccurate drawings, but they are using them to illustrate points that are highly disputed by leading embryologists. The earliest stages of vertebrate embryos are quite different and the existence of the cherry picked conserved stage often portrayed in textbooks as evidence for common ancestry is being called into question.

To say the least, students who are taught that the earliest stages of vertebrate embryos are highly similar, without being told of significant embryological evidence that challenges that view and the very existence of the conserved developmental stage portrayed in many textbooks, are not being adequately informed about the evidence regarding evolution.

### C. BIOGEOGRAPHY, *EXPLORE EVOLUTION*, AND THE NCSE<sup>278</sup>

In 2007, various skeptics of neo-Darwinism published a supplemental textbook titled *Explore Evolution: The Arguments For and Against Neo-Darwinism*. The textbook aims to bring a truly inquiry-based approach to studying evolution, as its introduction states:

The approach we are using in this book is called "inquiry-based" education. This approach allows you, the student, to follow the process of discovery, deliberation, and argument that scientists use to form their theories. It allows you to evaluate answers to scientific questions on your own and form your own conclusions. Our goal in using this approach is to expose you to the discoveries, evidence, and arguments that are shaping the current debates over the modern version of Darwin's theory, and to encourage you to think deeply and critically about them.<sup>279</sup>

As part of its inquiry-based approach, *Explore Evolution* provides students with both the "case for" and "case against" neo-Darwinian evolution in various lines of evidence common to treatments of evolution in most basal biology textbooks. One of those topics is biogeography.

In an online response to *Explore Evolution* regarding biogeography, the NCSE admitted that "If the [North American] opossum truly had roots in Australia, it would indeed be a biogeographic conundrum."<sup>280</sup> Why does the

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277. Matzke & Gross, *supra* note 164, at 41.

278. Portions of this section are adapted from a response to the NCSE's critique of *Explore Evolution* on Biogeography, Casey Luskin, *The NCSE's Biogeographic Conundrums: A Defense of Explore Evolution's Treatment of Biogeography*, [http://www2.exploreevolution.com/exploreEvolutionFurtherDebate/2010/01/the\\_ncses\\_biogeographic\\_conund.php](http://www2.exploreevolution.com/exploreEvolutionFurtherDebate/2010/01/the_ncses_biogeographic_conund.php) (last visited Jan. 26, 2010).

279. STEPHEN C. MEYER, ET AL., *Preface to Explore Evolution: The Arguments For and Against Neo-Darwinism*, (2007).

280. NCSEWEB.net, *Critique: Explore Evolution, Biogeography, Marsupials* (September 30<sup>th</sup>, 2008), <http://www.ncseweb.net/creationism/analysis/marsupials>; NCSE, *Biogeography* (Oct. 28, 2009) (on file with author).

NCSE hypothetically observe that it would pose a “biogeographic conundrum” if North American opossums *were* descended from Australian possums? The NCSE says this because there would be no land-based route by which Australian possums could have migrated to North America. The NCSE’s reasoning is sound: it presumes that if organisms in Locale B are descended from organisms in Locale A, then there must have been some migration route by which organisms could migrate from A to B. If there is no such route, then we’re presented with, in the NCSE’s own words, a “biogeographic conundrum.” Using such reasoning, the NCSE then argues that marsupials and other groups have biogeographic histories that are congruent with the migratory paths allowed by the tectonic history of islands and continents, thus supporting common descent:

The same pattern of diversification and migration seen in marsupials can also be seen in other groups of plants and animals. That consistency between biogeographic and evolutionary patterns provides important evidence about the continuity of the processes driving the evolution and diversification of all life. This continuity is what would be expected of a pattern of common descent, and is not what would be expected with the creationist orchard scheme.<sup>281</sup>

With marsupials, the NCSE claims that the “continuity” of geography and evolution predicts that there will always be some land bridge or migratory pathway which terrestrial organisms can follow.<sup>282</sup> This was claimed to allegedly show “consistency between biogeographic and evolutionary patterns” that demonstrates “what would be expected of a pattern of common descent.”<sup>283</sup> Ignoring the NCSE’s inappropriate usage of the “creationist” label, their claim is simply not true, for there are significant examples of terrestrial organisms existing and appearing in locations where no land-based migratory route is apparent. The NCSE’s approach is to cherry-pick examples to support their arguments for universal common descent, but serious “biogeographic conundrums” that challenge neo-Darwinism can be discussed.

Traditional evolutionary explanations of biogeography fail when terrestrial (or freshwater) organisms appear on an island or continent but there is no standard migratory mechanism for them to arrive from some ancestral population. What happens when organisms—even higher mammals—appear on isolated islands, and there appears no way for their purported ancestors to migrate there? At these points, evolutionary biogeographers appeal to a fallback position, a suite of mechanisms of “oceanic dispersal.” As a review by Alan De Quieroz stated:

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281. *Id.*

282. *Id.*

283. *Id.*

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A classic problem in biogeography is to explain why particular terrestrial and freshwater taxa have geographical distributions that are broken up by oceans. Why are southern beeches (*Nothofagus spp.*) found in Australia, New Zealand, New Guinea and southern South America? Why are there iguanas on the Fiji Islands, whereas all their close relatives are in the New World?<sup>284</sup>

According to De Queiroz, such examples require “oceanic dispersal over tectonic vicariance as an explanation for disjunct distributions in a wide variety of taxa, from frogs to beetles to baobab trees.”<sup>285</sup> But he recognizes a fundamental problem with overseas dispersal hypotheses: “cladistic biogeographers claimed that hypotheses of [oceanic] dispersal were not falsifiable because all patterns of relationships can be explained by some dispersal hypothesis.”<sup>286</sup> He further states, “A main objection to dispersal hypotheses is that they are unfalsifiable and thus unscientific.”<sup>287</sup> He continues that “this can be countered by noting that, if plausible vicariance hypotheses are falsified, then dispersal is supported by default.”<sup>288</sup>

In other words, neo-Darwinists assume that traditional land-based migration pathways were followed (the type of evidence the NCSE claims supports common descent). However, when such migration pathways are not an option, one can always fallback to unfalsifiable *ad hoc* hypotheses of oceanic dispersal. After reviewing a number of “unexpected” biogeographic data that require oceanic dispersal, De Queiroz’s review concludes that “these cases reinforce a general message of the great evolutionist [Darwin]: given enough time, many things that seem unlikely can happen.”<sup>289</sup>

Thus, neo-Darwinian evolutionists are forced to appeal to “unlikely” or “unexpected” transmigration of terrestrial organisms, in some cases requiring the crossing of oceans (“oceanic dispersal”) to account for some biogeographical data. Such data challenges the simplistic picture of biogeography put forth by the NCSE that biogeography lends support to universal common descent through congruence between migration pathways and tectonic history. If anything, the “disjunct distributions in a wide variety of taxa” would lend *prima facie* support for an orchard model of life’s history suggested by *Explore Evolution*, where universal common descent is false. A single tree of life hypothesis can only be sustained through extremely unlikely *ad hoc* appeals to oceanic dispersal to save

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284. Alan de Queiroz, *The Resurrection of Oceanic Dispersal in Historical Biogeography*, 20 *TRENDS IN ECOLOGY AND EVOLUTION*, 68, 68 (2005).

285. *Id.* (emphasis omitted).

286. *Id.* at 69.

287. *Id.* at 70.

288. *Id.*

289. *Id.* at 71.

universal common descent from biogeographical “conundrums.” What follows are some notable examples of such data.

### 1. *The Sea Monkey Hypotheses*

One of the most infamous examples of the very sort of “biogeographic conundrum” the NCSE fears is the origin of South American monkeys, called platyrrhines.<sup>290</sup> Based upon molecular and morphological evidence, “New World” platyrrhine monkeys are thought to be descended from African “Old World” or catarrhine monkeys. The problem is that plate tectonic history shows that Africa and South America split off from one another between 100 and 120 m.y.a., and that South America was an isolated island continent at least from about 80 m.y.a. until about 3.5 m.y.a.<sup>291</sup> Molecular studies claim that South American monkeys split from African monkeys perhaps around 35 m.y.a.<sup>292</sup> Monkeys are thought to have first evolved in Africa, and so somehow proponents of neo-Darwinism must account for the subsequent appearance of monkeys in the Upper Oligocene in South America.<sup>293</sup> As Walter Carl Hartwig puts it: “The platyrrhine origins issue incorporates several different questions. How did platyrrhines get to South America?”<sup>294</sup> In other words, *If the standard evolutionary story is true, and platyrrhines and catarrhines are both part of the same crown group radiation of monkeys, then how did platyrrhines come to be in South America if South America was then an isolated island continent and there was no land-based route for monkeys to migrate from Africa?*

For those unfamiliar with the arguments that proponents of neo-Darwinian biogeography make when backed into a corner, the answer to these questions is almost too incredible to believe: they propose that *monkeys floated on rafts* across the Atlantic Ocean to colonize South America. And of course, there cannot be merely one seafaring monkey, or the monkey will die leaving no offspring. Thus, at least two monkeys (or perhaps a single pregnant monkey) must have made the rafting voyage.

If this proposal seems a little farfetched, consider the quite serious

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290. See JOHN C. BRIGGS, GLOBAL BIOGEOGRAPHY 124 (1995); Alain Houle, *The Origin of Platyrrhines: An Evaluation of the Antarctic Scenario and the Floating Island Model*, 109 AMERICAN J. OF PHYSICAL ANTHROPOLOGY 541(1999).

291. See Carlos G. Schrago & Claudia A. M. Russo, *Timing the Origin of New World Monkeys*, 20 MOLECULAR BIOLOGY AND EVOLUTION 1620 (2003); John J. Flynn & André R. Wyss, *Recent Advances in South American Mammalian Paleontology*, 13 TRENDS IN ECOLOGY AND EVOLUTION 449 (1998); C. BARRY COX & PETER D. MOORE, BIOGEOGRAPHY: AN ECOLOGICAL AND EVOLUTIONARY APPROACH 185 (5<sup>th</sup> ed. 1993).

292. Schrago & Russo, *supra* note 291, at 1260.

293. ANTHONY HALLAM, AN OUTLINE OF PHANEROZOIC BIOGEOGRAPHY 166 (1995). See also Walter Carl Hartwig, *Patterns, Puzzles and Perspectives on Platyrrhine Origins*, in INTEGRATIVE PATHS TO THE PAST: PALEOANTHROPOLOGICAL ADVANCES IN HONOR OF F. CLARK HOWELL 80 (Robert S. Corruccini & Russell L. Ciochon, eds. 1994).

294. Hartwig, *supra* note 293, at 69.

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endorsement of the rafting hypothesis given in a recent authoritative book, *Primate Biogeography: Progress and Prospects*. John G. Fleagle and Christopher C. Gilbert, authors of the chapter “The Biogeography of Primate Evolution,” state the problem as follows:

The most biogeographically challenging aspect of platyrrhine evolution concerns the origin of the entire clade. South America was an island continent throughout most of the Tertiary, and most of the orders of mammals found in Paleocene through Miocene deposits are endemic families or orders almost exclusively restricted to that continent. Primates first appear in the Late Oligocene and become common only in the Early Miocene. Rodents also appear first in the Oligocene. Both groups are almost certainly immigrants from some other continent, and paleontologists have debated for much of this century how and where primates reached South America.<sup>295</sup>

Likewise, a Harper Collins textbook on human evolution states:

The origin of platyrrhine monkeys puzzled paleontologists for decades. . . . When and how did the monkeys get to South America?

Prior to about 1970, paleontologists invoked the concept of parallel evolution. . . . It seemed so unlikely that monkeys from Africa could cross a water barrier like the Atlantic Ocean. . . .

. . . Molecular evidence demonstrated that all monkeys shared a common ancestor prior to their separation. . . .

The “rafting hypothesis” argues that monkeys evolved from prosimians once and only once in Africa, and that it is a primitive monkey (parapithecoid), and not a prosimian, that made the water-logged trip to South America. . . . Other species colonizing South America must have arrived in similar ways over millions of years.<sup>296</sup>

As noted above, the high degree of genetic similarity between platyrrhine and catarrhine monkeys precludes the possibility that African and South American monkeys are similar simply because of convergent evolution. Yet as Fleagle and Gilbert state, similarities between monkeys across the oceans raises a difficult biogeographical issue because “South America is separated from Africa by a distance of at least 2600 km, making a phylogenetic and biogeographic link between the primate faunas of the two continents seem

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295. John G. Fleagle & Christopher C. Gilbert, *The Biogeography of Primate Evolution: The Role of Plate Tectonics, Climate and Chance*, in *PRIMATE BIOGEOGRAPHY: PROGRESS AND PROSPECTS* 393–94 (Shawn M. Lehman & John G. Fleagle, eds. 2006) (emphasis added).

296. ADRIENNE L. ZIHLMAN, *THE HUMAN EVOLUTION COLORING BOOK* 4–11 (2d. ed. 2000).

very unlikely.”<sup>297</sup> They argue that in light of “[t]he absence of any anthropoids from North America, combined with the considerable morphological evidence of a South American-African connection with the rodent and primate faunas” that therefore “the rafting hypothesis is the most likely scenario for the biogeographic origin of platyrrines.”<sup>298</sup>

All kinds of arguments have gone back and forth about whether such a rafting journey is even plausible. Of course millions of years ago Africa and South America were slightly closer than they are today, but they were still very far apart at the time monkeys supposedly colonized South America. Fleagle and Gilbert argue that at best, the position of the continents in the early Tertiary still requires a “journey from Africa to South America anywhere from 8 to 15 days.”<sup>299</sup> This is called “plausible,” but a macroview must be taken here: *Is there any real biogeographical evidence that can falsify common ancestry?* If the presence of higher mammalian fauna on isolated island continents with no simple way to arrive there does not falsify neo-Darwinian explanations of biogeography, what will?

Indeed, the rafting hypothesis has serious problems, for monkeys and rodents have high metabolisms and require large amounts of food and water:

The case of platyrrhines is more difficult to explain as anthropoid primates have higher metabolic rates and do not have the ability for prolonged periods of torpor. A two-week rafting event across the Atlantic must have involved a floating island with an adequate food and water supply.<sup>300</sup>

Such “floating islands” are said to exist, but they admit that “the prevalence of over-water dispersal during primate evolution seems truly amazing for a mammalian order.”<sup>301</sup> They further admit that “[t]he reasons for the prevalence of rafting during the course of primate evolution remain to be explained.”<sup>302</sup>

Needless to say, not all feel comfortable believing that seafaring monkeys on rafts are “plausible.” As Hartwig states, “[t]he overwhelming evidence for the late Cretaceous-Pliocene isolation of South America renders the mechanical aspect of platyrrhine dispersal virtually irresolvable,”<sup>303</sup> for “any late Eocene origins model must invoke a transoceanic crossing mechanism that is implausible (rafting) or suspect

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297. Fleagle & Gilbert, *supra* note 295, at 394.

298. *Id.* at 394-95.

299. *Id.* at 394 (internal citations omitted).

300. *Id.* at 404.

301. *Id.*

302. *Id.* at 403.

303. Hartwig, *supra* note 293, at 76.

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(waif dispersal) at best.”<sup>304</sup>

And there are deeper problems: monkeys apparently made the journey, but other smaller African primates such as lorises and galagos never colonized South America. If it was so easy for monkeys to raft across the proto-Atlantic ocean, why did lower primates not also make the voyage? The answer given by Fleagle and Gilbert is that rafting is “clearly a chance event, an example of ‘sweepstakes’ dispersal” as “[o]ne can only speculate that by *a stroke of good luck* anthropoids were able to ‘win’ the sweepstakes while lorises and galagos did not.”<sup>305</sup> As another authority wrote, “[t]he evidence strongly suggests the existence of a Palaeogene transoceanic sweepstakes route between Africa and South America, and presumably also a similar route between Africa and Madagascar” to explain such disparate primate distributions.<sup>306</sup>

Apparently the NCSE was not quite accurate when claiming that “[b]y comparing macroevolutionary patterns between different groups, we find that the same patterns repeat. This strongly suggests that the same forces drove the diversification of those different groups.”<sup>307</sup> The truth is that whenever oceanic “sweepstakes” dispersal is required, we find an exception to expected neo-Darwinian rules of biogeography.

When proponents of neo-Darwinism “speculate” about the “luck” and “chance” needed to explain this “amazing” phenomenon and “challenging” biogeographical data, it seems clear that they lack reasonable explanations. Yet rafting or other means of “oceanic dispersal” have been suggested to solve a number of other biogeographical conundrums that challenge neo-Darwinism. There are so many exceptions that one might reasonably question whether the inviolable neo-Darwinian rule of universal common ancestry is supported by biogeography.<sup>308</sup>

## 2. *Testing the Orchard Model and the NCSE’s Claims About the Existence of “Nested Patterns” Supporting a “Tree of Life”*

When constructing evolutionary trees, evolutionary biologists initially assume that high functional biological similarity is evidence of common ancestry. Such assumptions are ubiquitous, as one authority explains that “[t]he assumption of homology is implicit in comparison of character states; that is, all states of a character derive from the same ancestral state.”<sup>309</sup> But

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304. *Id.* at 84. Note: “waif dispersal” in this case refers to “island-hopping.”

305. Fleagle & Gilbert, *supra* note 295, at 395 (emphases added).

306. HALLAM, *supra* note 293, at 166.

307. National Center for Science Education, Fixity of Species (September 30, 2008), <http://ncse.com/creationism/analysis/fixity-species>.

308. For a review of just some of these examples, *see, e.g.*, Alan de Queiroz, *The Resurrection of Oceanic Dispersal in Historical Biogeography*, 20 TRENDS IN ECOLOGY AND EVOLUTION 68 (2005).

309. LAURIE J. VITT & JANALEE P. CALDWELL, HERPETOLOGY 26 (3d. ed. 2009).

when high similarity is not evidence of inheritance from a common ancestor, as is the case for many similarities between marsupial and placental mammals, the “assumption of homology,” which forms the bedrock for all evolutionary trees, *breaks down*. A recent treatise published by Harvard University Press laments how convergent (or independent) evolution causes severe problems for evolutionary phylogenies:

Cladistics can run into difficulties in its application because not all character states are necessarily homologous. Certain resemblances are convergent—that is, the result of independent evolution. We cannot always detect these convergences immediately, and their presence may contradict other similarities, “true homologies” yet to be recognized. Thus, we are obliged to assume at first that, for each character, similar states are homologous, despite knowing that there may be convergence among them.<sup>310</sup>

Another authority notes that “the assumption of homology . . . was necessary to deduce a pattern of relationships.”<sup>311</sup> But what happens if that assumption is false? The reality is that “the assumption of homology implies common ancestry,” without this assumption, the methodology used to infer common descent collapses.<sup>312</sup>

The textbook *Explore Evolution* finds that there are many cases where that primary assumption is false, and offers the “orchard model” as an alternative to neo-Darwinian notions of universal common descent to explain the data.<sup>313</sup> Under the orchard model, “the history of life looks more like an orchard of separate trees” rather than one single tree.<sup>314</sup> The NCSE argues against the orchard model and in favor of a monophyletic “universal common descent” view of life, arguing that “[t]he consistency of these trees cannot be explained without reference to common descent. The creationist ‘orchard’ is scientifically vacuous.”<sup>315</sup>

The NCSE’s claim is perplexing because, as noted, the NCSE also claims that “continuity [between biogeographic and evolutionary patterns] is what would be expected of a pattern of common descent, and is not what

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310. GUILLAUME LECOINTRE & HERVÉ LE GUYADER, *THE TREE OF LIFE: A PHYLOGENETIC CLASSIFICATION* 16 (2006).

311. David R. Begun, *Hominid Family Values: Morphological and Molecular Data on Relations Among Great Apes and Humans*, in *THE MENTALITIES OF GORILLAS AND ORANGUTANS: COMPARATIVE PERSPECTIVES* 8 (Sue Taylor Parker, et al. eds. 1999).

312. Olivier Rieppel, *What Happens When the Language of Science Threatens to Break Down in Systematics: A Popperian Perspective*, in *MILESTONES IN SYSTEMATICS* 78 (David Malcolm Williams & Peter L. Forey, eds. 2004).

313. See STEPHEN C. MEYER, ET AL., *supra* note 279, at 39–61.

314. *Id.* at 10.

315. National Center for Science Education, *Biogeography*, <http://ncse.com/book/export/html/1505> (last visited Jan. 26, 2010).

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would be expected with the creationist orchard scheme.”<sup>316</sup> Ignoring the NCSE’s continued inappropriate use of the “creationist” label, the NCSE is committing a classic fallacy by arguing that views opposing neo-Darwinism are *both unfalsifiable, and falsified by the data.*

Regardless, the NCSE is wrong to claim that the orchard model makes no predictions. If a monophyletic view of common descent predicts “nested patterns,” then by its own admission a polyphyletic or “orchard” view predicts non-nested patterns. Indeed systematists regularly search for precisely such non-nested patterns in order to identify polyphyletic taxa, a phenomenon effectively predicted by the orchard model. The only idea here that is “meaningless” is the NCSE’s claim that universal common descent makes predictions, while the “orchard” model does not (and, by the way, is falsified due to its failed predictions).

In fact, biogeography is full of incongruent patterns, which essentially entail non-nested distribution of species. Bruce S. Lieberman’s treatise *Paleobiogeography: Using Fossils to Study Global Change, Plate Tectonics, and Evolution* compares the problem of finding incongruent (i.e., non-nested) patterns among different biogeographic hypotheses to the problem of finding incongruent (i.e., non-nested) patterns of traits in different species when constructing phylogenetic trees:

[H]istorical biogeography is the discipline that looks at how groups of organisms have evolved and how their geographic distributions have changed in relation to geological or climatic events. . . . In phylogenetic analysis, the arbiter among competing hypotheses suggested by different character systems, i.e. incongruence among characters, is parsimony. The analogous problem in biogeography is what to do when one group suggests one biogeographic pattern, and another group suggests another.<sup>317</sup>

In Lieberman’s words, when “one group suggests one biogeographic pattern, and another group suggests another,” we have a non-nested biogeographical pattern and find the opposite of the NCSE’s claimed “continuity” that supports universal common descent. The origin of South American platyrrhine monkeys discussed above is a prime example, among many.

In fact, it is not only within biogeography that we find non-nested patterns, and it is important to fact-check the NCSE’s claim that we always find “nested patterns” pointing to a single “tree of life.” As noted earlier, a January 2009 article in *New Scientist* titled *Why Darwin Was Wrong about the Tree of Life* contradicts the NCSE’s claim of consistently “nested

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316. NCSEWEB.net, *supra* note 280.

317. BRUCE S. LIEBERMAN, *PALEOBIOGEOGRAPHY: USING FOSSILS TO STUDY GLOBAL CHANGE, PLATE TECTONICS, AND EVOLUTION* 114 (2000).

patterns” in the tree of life, which “cannot be explained without reference to common descent.”<sup>318</sup> Rather, the article reported a major “problem” encountered by molecular systematists, namely that “different genes told contradictory evolutionary stories.”<sup>319</sup> This of course led one scientist to say that “[w]e’ve just annihilated the tree of life” with regards to the relationships of higher groups.

In reconstructing the “tree of life,” striking admissions also came from a paper in the journal *PLoS Biology*, titled *Bushes in the Tree of Life*, which acknowledges that “a large fraction of single genes produce phylogenies of poor quality.”<sup>320</sup> The paper observes that one study even “omitted 35% of single genes from their data matrix, because those genes produced phylogenies at odds with conventional wisdom.”<sup>321</sup> The paper suggests that “certain critical parts of the [tree of life] may be difficult to resolve, regardless of the quantity of conventional data available.”<sup>322</sup> Furthermore, the paper adds that “[t]he recurring discovery of persistently unresolved clades (bushes) should force a re-evaluation of several widely held assumptions of molecular systematics.”<sup>323</sup>

Unfortunately, one assumption that these evolutionary biologists are *not* willing to consider changing is that neo-Darwinism and universal common ancestry are correct. Meanwhile, as far as the data is concerned, the *New Scientist* article admits, “[e]ver since Darwin the tree has been the unifying principle for understanding the history of life on Earth,” but because “different genes told contradictory evolutionary stories,” the notion of a tree of life is becoming a vision of the past—as the article stated, the tree is being “annihilated.”<sup>324</sup>

The NCSE claims that the “orchard” concept of *Explore Evolution* is meaningless, but it seems to predict the precise non-nested phylogenetic data reported in *New Scientist* and the non-nested biogeographic data discussed above. Perhaps the reason why different genes are telling “different evolutionary stories” and the fact that “one group suggests one biogeographic pattern, and another group suggests another” is because some genes and organisms have wholly different stories to tell, which indicate that not all living organisms are ancestrally related, thereby fulfilling a testable prediction of the orchard model.

There are fundamental incongruities within the data used to support common descent, and alternative explanations, such as the orchard model,

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318. National Center for Science Education, *supra* note 315.

319. Lawton, *supra* note 235.

320. Antonis Rokas & Sean B. Carroll, *Bushes in the Tree of Life*, 4 PLOS BIOLOGY 1899, 1902 (2006) (internal citations and figures omitted).

321. *Id.*

322. *Id.* at 1900.

323. *Id.*

324. Lawton, *supra* note 235.

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are capable of better explaining much data. Students could be exploring these scientific questions instead of being taught the dumbed-down, and the ultimately false view that there is “continuity” between essentially all lines of evidence to support common descent. The evolution lobby suggests that students learn this oversimplified version of the data, which glosses over significant challenges to neo-Darwinian thinking. Allowing students to study and discuss challenges posed by this data will not only help them better understand evolutionary biology, but will make them better scientific thinkers. Maybe one day they will be inspired to discover the answers to these biogeographic conundrums once and for all.

## V. CONCLUSION

Not only is it perfectly legal to engage in a scientific critique of modern evolutionary biology, but it results in many pedagogical benefits. The inquiry-based method is the ideal way to teach science. It eschews rote memorization and dogmatism, and instead helps students learn scientific content by learning processes of reasoning and habits of mind employed by scientists when evaluating scientific claims. The benefit of the inquiry-based method is a scientifically literate population that is more likely to participate in and support the scientific enterprise. This makes it all the more egregious that leading science education authorities—who claim to support inquiry-based science education—do not encourage meaningful investigation when studying evolution. The result is a system of science standards, textbooks, and educators who present to students (at the behest of the evolution lobby) a dumbed-down, oversimplified, and ultimately inaccurate picture of the scientific data pertaining to biological origins. This not only fails to inform students of scientific facts, but it fails to inspire students to become interested in science.

The most effective, accurate, and pedagogically beneficial way to teach evolution is to allow students to explore the scientific evidence both for and against prevailing theories of evolution. Given the prevalence of scientific criticisms of textbook treatments of evolution in mainstream scientific literature, and the well-recognized pedagogical benefits of using the inquiry-based method in teaching science, school boards will readily find the secular justification needed to study evolution objectively, skeptically, and critically—to treat neo-Darwinism like a science in the classroom.