

## Critical Analysis of Evolution: Poor Pedagogy (approach to teaching)

The lesson fails from an effective teaching standpoint. Instead of having students model the scientific method and encouraging critical thinking, the lesson presents scripted arguments and calls for rote copying of material presented by the teacher. These materials include a series of incorrect definitions of technical terms, and errors of fact drawn straight from the creationist literature. The “aspects” of evolutionary theory are presented as controversies (as drawn from the creationist literature) and the format of the class discussion is essentially as debate. This is not how science is done. Critical analysis in science involves evaluation of multiple working hypotheses against a body of evidence (measurements, observations, modeling). Hypotheses that are better supported by the evidence gather the most support – and lead to more testing by other researchers. Hypotheses which are shown through extensive testing to have strong explanatory power, and which link well with other areas of knowledge, are raised to the level of a theory.

This lesson should carry a warning label that the evidence said to challenge aspects evolutionary theory has never been confirmed through the scientific process. This lesson also fails to reference the many peer-reviewed scientific publications which completely refute the supposed “scientific challenges” to evolutionary theory.

Critical Analysis of Evolution – Grade 10 (Lesson: L10-H23)	Intelligent Design Creationism sources	What scientists say:
<p>1 <b>Scientific Ways of Knowing Benchmark A</b></p> <p>pp. 313 - 314 Explain that scientific knowledge must be based on evidence, be predictive, logical, subject to modification and limited to the natural world.</p> <p><u>Indicator 3</u> Recognize that science is a systematic method of continuing investigation, based on observation, hypothesis testing, measurement, experimentation, and theory building, which leads to more adequate explanations of natural phenomena.</p>	<p>SEAO, “<i>The evolution controversy</i>.” “Since evolutionary theory assumes that life came about only by natural causes, it purposely (and wrongly) excludes from consideration any hypothesis that involves intelligent or supernatural causes.” (Sjogren, et al., 2003, p.4).</p> <p><b>Sjogren continues...</b> “Douglas Futuyma, author of a college-level text entitled <i>Evolutionary Biology</i>, says in his preface to the student, “‘All the biological sciences rest on two central principles. One is that all life processes have an entirely physical and chemical (i.e. material) basis. The other is that all organisms and their characteristics are products of evolution.’ (Douglas J. Futuyma. <i>Evolutionary Biology, Third Edition</i>. Sinauer Associates, Inc., 1998.)</p> <p>“Futuyma comments on the revolution that this way of thinking has caused in Western thought, and then compares evolution to its apparent arch-enemy, divine creation, in a summary statement in the first chapter of the book: “‘Darwin’s evolutionary theory, published in <i>The Origin of Species</i> in 1859, consisted of the hypotheses that (a) all organisms have descended, with modification, from common ancestral forms of life, and (b) a chief agent of modification is natural selection. The implications of this theory, which revolutionized Western thought, include (a) change, rather than stasis, is the natural order; (b) biological phenomena, including those seemingly designed, can be explained by purely material causes, rather than by divine creation; (c) no evidence of purpose or goals can be found in the living world, other than in human actions .... (emphasis added). (Ernst Mayr.</p>	<p>The lesson in question is proposed to meet the benchmark indicator of demonstrating how <u>scientists</u> critically examine aspects of evolutionary theory. Thus, the indicator imposes two requirements: 1) a consideration of <u>current</u> topics in evolutionary biology; and 2) an examination of science as it is carried out by mainstream scientists working within the framework of the scientific method.</p> <p>The statements quoted from Sjogren, et al. (2003) summarize one of the most fundamental and important distinctions between 1) science and the scientific method, and 2) the philosophy advocated by Intelligent Design Creationists.</p> <p>Science is restricted to observing, measuring, and testing in the natural world, as noted in the Science standards. This is not a philosophy, it is a fundamental limitation of the scientific method. As such, science cannot consider causal explanations outside the natural world.</p> <p>Intelligent Design regards the limitations of science as an expression of a philosophical perspective. The quotations</p>

<p><b>1a. Pre-Assessment:</b>  <b>pg. 313</b> Instruct students to copy the following items from the chalkboard in their science lab notebook.</p> <ol style="list-style-type: none"> <li>1. Describe what constitutes a scientific anomaly.</li> <li>2. Why do anomalies exist in science?</li> <li>3. Are there benefits to exploring scientific anomalies?</li> <li>4. How do scientists critically analyze conflicting data?</li> <li>5. Define the following terms in your own words:       <ul style="list-style-type: none"> <li>&lt; theory</li> <li>&lt; Critical Analysis</li> <li>&lt; Natural Selection</li> <li>&lt; Biological evolution</li> <li>&lt; Macroevolution</li> <li>&lt; Microevolution</li> </ul> </li> </ol> <p>Direct students to respond to the questions in their science notebook in as much detail as possible leaving space to record information from the ensuing dialogue to add to their notes.</p>		<p>This pre-assessment does nothing to inform the teacher about the student's level of knowledge or understanding of the lesson topic. The next step in the process is for teachers to collect the pre-assessments; however, this is impossible if students retain their notebooks as directed.</p> <p>In reality, this very prescriptive activity allows/directs the teacher to impose on the students an incorrect set of terms designed to pave the way for an invented set of controversies regarding evolution (see companion discussion, "Accuracy in scientific content").</p>
<p><b>2</b>  <b>pg. 315</b></p> <ul style="list-style-type: none"> <li>•Describe three major pieces of evidence used to challenge evolution and explain why these pieces are important.</li> <li>•Compare and contrast the supporting and challenging information regarding the aspect of evolution you studied.</li> <li>•Evaluate the scientific data supporting and challenging areas of evolution in light of the scientific method. In other words, is the data that is used to support or challenge evolution consistent or inconsistent with the scientific method? Are there any limitations? (NOTE: steps of scientific method: Observation</li> </ul>	<p><i>The Wedge: A Progress Report.</i>  Phillip E. Johnson  Berkeley, California, April 16, 2001</p> <p>Approximately ten years ago, I formulated the Wedge strategy with two related goals. The first was to legitimate the topic of intelligent design, and hence the critique of Darwinism and its basis in naturalistic philosophy, within the mainstream intellectual community. The second was to make the critique of naturalism the central focus of discussion in the religious world, replacing the deadlocked debate over the Genesis chronology which had enabled the Darwinists to employ the "Inherit the Wind stereotype" so effectively. The goals are intertwined because the approach which is capable of challenging the dominant philosophy in the secular world will also tend to attract the most interest in the religious world."</p> <p>One key development has been the publication of so many excellent</p>	<p>From "Indicator 23: "Describe how scientists continue to investigate and critically analyze aspects of evolutionary theory. (The intent of this indicator does not mandate the teaching or testing of intelligent design.)"</p> <p>Indicator #23 and related standards do not list "evidence against evolution" or "evidence challenging evolution." The focus of the indicator is to "investigate ... <b>aspects</b> of evolutionary theory."</p> <p>The switch in terminology away from the benchmark indicator shifts the assignment away from the common scientific activity of critically analyzing cutting edge research</p>

<p>3 p. 316</p>	<p>2. Ask students to think through the following science topics and discuss where anomalies led to the collection of data that further explained the phenomena and contributed to changing scientific understandings.</p> <ul style="list-style-type: none"> <li>•Spontaneous generation versus biogenesis Several pieces of data could be used. One example is Francesco Redi’s observation that flies must contact meat in order for maggots to appear on the meat.</li> </ul>	<p>SEAO, “<i>The evolution controversy:</i>”</p> <p>The debate over evolution and spontaneous generation was resolved nearly a century and a half ago. Creationists now like to coin the term “biogenesis” and even refer to the “Law of Biogenesis.” (see for example <a href="http://www.creationscience.com/onlinebook/ReferencesandNotes3.html">www.creationscience.com/onlinebook/ReferencesandNotes3.html</a> ). The intent is to show that evolutionary mechanisms can’t explain the origin of life. This is a contrived controversy as the Theory of Evolution only deals with changes in living organisms once life began – it is silent on the mechanism of how life originated.</p>	<p>The section on “student engagement” misleads students by tying evolution to “spontaneous generation” etc. This invites students to make a common error – conflating issues of the initial origin of life (chemical evolution) on earth with the rather different field of biological evolution. It would be more useful to draw from recent examples of the expansion of knowledge in Biology by the acquisition of wholly new information. The close correspondence of the molecular “tree of life” with the earlier physical taxonomic tree is one such example.</p>
<p>4 p. 316</p>	<p>2. Ask students to think through the following science topics and discuss where anomalies led to the collection of data that further explained the phenomena and contributed to changing scientific understandings.</p> <ul style="list-style-type: none"> <li>•Global warming versus non global warming Several pieces of data could be used. One example is the observed increasing size of the hole in the ozone layer.</li> </ul>		<p>The lesson plan’s discussion of global warming is confused and misleading, and not well linked to the lesson’s topic. Global warming is a fact as shown by historical records and geologic data spanning the last 400,000 years. No “anomalous” body of data led to major changes in the theories related to warming of the Earth. Current active research involves determining the rate of planet-wide warming; how much human activity contributes to the observed warming trends; how greenhouse gases are generated and fixed in the natural environment; and whether changes in human activities will have a long-term impact on warming. At a policy level there is active debate on how to best plan for the consequences of a warmer planet. This is a great discussion for a different benchmark.</p>

<p>5 p. 317</p>	<p><b>Student Research</b> 6. Allow the groups to pick (or assign) one of the five aspects of evolutionary theory. Assign two groups to research each aspect. The aspects are: Aspect 1: Homology (anatomical and molecular) Aspect 2: Fossil Record Aspect 3: Anti-Biotic Resistance Aspect 4: Peppered Moths Aspect 5: Endosymbiosis</p>	<p>Chapters in Rev. Jonathan Wells' <i>Icons of Evolution</i> compare closely with the lesson aspects: 3. Darwin's Tree of Life (aspect 2) 4. Homology (aspect 1) 6. Fossils/Cambrian (aspect 2) 7. Peppered Moths (aspect 4) 9. Mutations/Variation (aspect 3) 10. Fossils/Directed Evolution (aspect 2)</p> <p>The three major types of evidence that are used to support evolutionary theory (macroevolution) are the fossil record, homologies, and embryology. The principal features of the fossil record are the abrupt appearance of new species (<i>e.g.</i>, the Cambrian explosion), stasis (equilibrium) over long periods of time, and then extinction. This discontinuous pattern is more consistent with the theory of intelligent design. Homologies are similarities in structure and form among different organisms. Homologies may suggest either a common ancestry or a common designer (archetype), depending on how the evidence is interpreted. The argument from embryology proposes that similarities in the stages of developing embryos from different species suggest a common ancestry. However, the findings of modern embryology show that embryos from different organisms are different at all stages of development. (Sjogren, et al., 2003, p.5)</p> <p>With regard to teaching the evidence, we suggest that at least three types be covered – fossils, homologies, and embryology. Modern definitions of science are typically naturalistic, <i>e.g.</i>, science is finding “natural explanations for natural phenomena.” Students should know that this type of definition is controversial, and that science also has the capability to empirically detect when non-naturalistic (<i>e.g.</i>, intelligent) causes may be at work. We believe that teachers should have the freedom to discuss scientific alternatives to evolution, if they so choose, and that they should not be required to provide only a “natural explanation” of how life arose on earth. (Sjogren, et al., 2003, p.5)</p>	<p>Of the 5 selected “aspects”, none represent areas of significant controversy or challenge to basic evolutionary concepts within the world of active biological research.</p> <p>The 5 aspects, however, are common themes in the creationist literature. Four of five aspects in this lesson correspond to material in <i>Icons of Evolution</i>. “Aspect 5: Endosymbiosis” appears to draw on material from Behe's <i>Darwin's Black Box</i>.</p>
<p>6 p. 318</p>	<p><b>Critical Analysis Activity</b> 9. Allow the students to spend time researching and preparing for the critical analysis activity on both the supporting and challenging information. Prior to the activity, randomly determine which of the two groups will present supporting information and which will present challenging information. You may</p>	<p>Discovery Institute, Center for (the Renewal of) Science and Culture, Web Curriculum, Science Education Resources:</p> <p>The Discovery Institute published (on the Internet) an educational curriculum that encouraged <i>student debates</i> and <i>role plays</i> of scientists promoting evolution or Intelligent Design in <i>March, 2000</i>, (Forrest &amp; Gross, 2004). These materials have since been restricted or are completely unavailable. See Forrest and Gross, (2004), for the details. From the archives maintained by Forrest and Gross:</p>	<p>The “critical analysis activity” is a modification of the pedagogically defective debate format of earlier versions of this lesson. A format that encourages students to take sides is decidedly not a scientific research method reflecting how scientists analyze competing theories, and it is highly questionable for the effective teaching of science.</p>

7 p. 332	<b>Critical Analysis Activity</b> Attachment C – Critical Analysis Rubric 1. Group was able to articulate and demonstrate knowledge of the aspect of evolution they presented.		1. No points are given for the accuracy, currency, or completeness of the evidence presented. Given that the challenge positions for the “aspects” are based on misinformation and inaccurate depiction of concepts involved, at least half the students will end up with misconceptions of evolutionary biology.
	2. Students were courteous and respectful toward their fellow students.		2. Respect for others should be a ground rule for all classrooms and shouldn’t be singled out for scoring in this one lesson.
	3. Students were able to effectively use research (scientific data) to support their presentation.		3. There are no guidelines or criteria presented in this lesson plan as to what sources of information are acceptable. Many creationist or Intelligent Design references appear to present scientific data – only on close inspection can it be shown that the information is inaccurate, misrepresents the original source material, or that conclusions drawn ignore important data. Tenth Grade high school students do not have the background knowledge or skills to distinguish accurate scientific information from pseudo-science.

Contributors to this table (alphabetical order):

Tom Baillieul,  
Richard Hoppe,  
Steve Rissing,

Barbara Forrest,  
Keith Miller,  
Ted Scharf,

John Geohegan,  
Ken Miller,  
Dave Thomas,

Alan Gishlick,  
Patricia Princehouse,  
Jon Woolf

References:

Baillieul, T. (2004). Analysis and review of cited references in OBE Lesson L10-H23. [http://ecology.cwru.edu/ohioscience/References\\_analysis.html](http://ecology.cwru.edu/ohioscience/References_analysis.html)

Behe, M. (1996). *Darwin’s black box: The biochemical challenge to evolution*. New York, The Free Press.

Forrest, B., and Gross, P.R. (2004). *Creationism’s Trojan Horse: The wedge of Intelligent Design*. Oxford, Oxford University Press.

Hoppe, R.B., Princehouse, P., and, Mckee, J. (2004). Examples of errors in “Critical Analysis of Evolution” (OBE Lesson L10-H23).

Majerus, (1998).

ˆ  
Sjogren, J.F., Lattimer, R.L., and Rudy, D.D. (2003). The evolution controversy: *Understanding the basic issues in the debate between biological evolution and Intelligent Design*. Science Excellence for All Ohioans: [www.sciohio.org](http://www.sciohio.org)

Wells, J. (2000). *Icons of evolution: Science or myth?* Washington, D.C., Regnery Publishing, Inc.