A Preliminary Analysis of the Treatment of Evolution in

Biology Textbooks

currently being considered for adoption by the

Texas State Board of Education

Center for Science and Culture
Discovery Institute
1511 Third Avenue, Suite 808
Seattle, WA 98101
(206) 292-0401, x107

INTRODUCTION AND EXECUTIVE SUMMARY

The following analysis examines the treatment of Darwinian evolution in eleven biology textbooks currently being considered for adoption by the Texas State Board of Education. This preliminary review focuses on four standard topics that are prominent in textbook treatments of evolutionary theory, and it analyzes whether each topic is covered in a manner that is "free from factual errors" (Texas Education Code, § 31.023) and that enables students to "analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information." (TEKS §112.43c(3)A).

This analysis concludes that all eleven textbooks repeatedly fail to meet the Texas requirements for accuracy and critical analysis. As a general rule, the textbooks cover the scientific evidence for Darwinian theory uncritically, without identifying the theory's scientific weaknesses as well as its strengths. In the process, the textbooks also misrepresent published scientific evidence and teach a number of serious factual errors. To summarize the findings:

- Four of the textbooks (BSCS Human Approach, Raver, Biggs et al., and Starr & Taggart) receive an overall grade of F for their serious and repeated misrepresentations of the scientific evidence.

- Six of the textbooks (Purves et al., Raven & Johnson, BSCS Ecological Approach, Mader, Johnson & Raven, and Miller & Levine) receive an overall grade of D or D- for their misleading and inadequate presentation of the scientific evidence.

- One textbook (Campbell & Reece) receives an overall grade of C- for its minimally acceptable presentation of the scientific evidence.

- One textbook (Raver), in addition to receiving a failing grade for its misrepresentations of the scientific evidence, is also noted for making several egregiously false statements about the history of science.

Study Methodology

The textbooks were examined for their coverage of the following topics: (1) the 1953 Miller-Urey experiment that produced chemical building blocks of life from a simulated primitive atmosphere of methane, ammonia, hydrogen and water vapor; (2) the Cambrian explosion, in which the major groups of animals appeared relatively suddenly in the fossil record rather than branching off from a common ancestor, as Darwin's "tree of life" implies; (3) drawings or pictures of similarities in vertebrate embryos that are likewise used as evidence of common ancestry; and (4) drawings or pictures of peppered moths resting on tree trunks,

used to illustrate experiments demonstrating natural selection. The first few pages of the analysis contain background information (including references) for each of these topics.

Each textbook is then analyzed individually, beginning with the oldest. In addition to being evaluated for treatment of the four topics, some of the textbooks are also evaluated for their descriptions of historical disputes and current controversies involving science and religion. The evaluations of individual textbooks are followed by a summary comparing the results, and an appendix listing the specific criteria used to evaluate each topic.

This analysis was prepared by staff and fellows of the Center for Science and Culture in Seattle, WA. The Center is a project of Discovery Institute, a not-for-profit public policy organization. The Center for Science and Culture is committed to the accurate presentation of evidence and arguments for and against Darwinian evolution and its alternatives. Center Fellows include biologists, biochemists, physicists, mathematicians, philosophers and historians of science, and other scholars with Ph.D.s in their respective fields. Many of the Center's fellows also have affiliations with colleges and universities. For more information, please consult the Center's web site at http://www.disccovery.org/crsc.

INDEX

TOPIC I
The 1953 Miller-Urey Experiment

Charles Darwin's theory of evolution applies to living things; Darwin did not propose a theory about the origin of life itself, other than to speculate that life may have begun in a "warm little pond" (Francis Darwin, ed., *The Life and Letters of Charles Darwin*, Vol. 2, p. 202). It wasn't until the early 1950s that University of Chicago graduate student Stanley Miller performed an experiment in the laboratory of his professor, Harold Urey, that ushered in modern origin-of-life research.

In the early 1950s, scientists believed that the atmosphere on the early Earth consisted mainly of water vapor, hydrogen and hydrogen-rich gases such as methane and ammonia. Miller put these gases into a glass apparatus and passed them through an electric spark to simulate lightning. A week later, he found that the apparatus contained a mixture of organic molecules that included a few amino acids -- the building blocks of proteins. After he reported his results in 1953, Miller's experiment was incorporated into many biology textbooks to show that scientists were beginning to understand the origin of life.

In the 1960s, however, geochemists realized that the early Earth's atmosphere probably contained little hydrogen (which, being so light, would have been lost to outer space), but consisted instead of volcanic gases such as carbon dioxide and nitrogen. When the Miller-Urey experiment is repeated with carbon dioxide (CO_2), nitrogen (N_2) and water vapor instead of hydrogen, methane, ammonia and water vapor, no amino acids are produced. By 1980, most geoscientists had concluded that the Miller-Urey experiment was largely irrelevant to the origin of life.

Yet textbooks continue to feature the experiment, complete with photographs or drawings of Miller's original apparatus, as evidence that life's building blocks could have formed spontaneously on the early Earth. Many textbook accounts of the Miller-Urey experiment fail to inform students that the Earth's early atmosphere was probably quite different from the mixture of gases used in the experiment, or that when the experiment is repeated with a realistic mixture it does not work. Even textbooks that hint at problems with the 1953 experiment typically tell students that more realistic gas mixtures still produce "organic molecules," without informing students that those molecules include toxic chemicals such as cyanide and formaldehyde but do not include amino acids.

The truth is that scientists are as far as ever from understanding how life's building blocks formed on the early Earth, and even farther from understanding how cells formed from such building blocks. Yet instead of informing students that the origin of life remains an impenetrable mystery, most biology textbooks give students the false impression that scientists have made great strides in understanding it. Since they misrepresent the significance of the now-discounted Miller-Urey experiment, and mislead students about current state of origin-of-life research, such textbooks cannot enable students to "analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information" (Texas Education Code, § 31.023).

Miller-Urey Experiment Bibliography

Articles in scientific publications:

Klaus Dose, "The Origin of Life: More Questions Than Answers," *Interdisciplinary Science Reviews* 13 (1988): 348-356.

John Horgan, "In the Beginning...," *Scientific American* (February, 1991): 116-126.

Gordon C. Mills, Malcolm Lancaster & Walter L. Bradley, "Origin of Life & Evolution in Biology Textbooks -- A Critique," *The American Biology Teacher* 55 (February, 1993): 78-83.

James F. Kasting, "Earth's Early Atmosphere," *Science* 259 (1993): 920-926.

Jon Cohen, "Novel Center Seeks to Add Spark to Origins of Life," *Science* 270 (1995): 1925-1926.

Leslie E. Orgel, "The origin of life: a review of facts and speculations," *Trends in Biochemical Sciences* 23 (1998): 491-495.

Articles in newspapers:

Nicholas Wade, "Life's Origins Get Murkier and Messier," *The New York Times*, June 13, 2000, pp. D1-D2.

Book:

Robert Shapiro, *Origins: A Skeptic's Guide to the Creation of Life on Earth* (New York: Summit Books, 1986).

TOPIC II
Darwin's Tree of Life & The Cambrian Explosion

Darwin called his theory "descent with modification." The term "descent" reflected Darwin's belief that all organisms are descended from a common ancestor that lived in the distant past. The only illustration in Darwin's book *The Origin of Species* shows the "tree of life" pattern one would expect to find in the fossil record if Darwin's theory were true. The common ancestor would come first, at the base of the tree; minor differences among individuals would eventually become different species, and the major differences that distinguish modern groups of organisms (called "phyla") would come last. Major phyla include the annelids (earthworms and leeches), mollusks (clams and snails), arthropods (lobsters and insects), echinoderms (starfish and sea urchins) and chordates (fishes and mammals).

In the fossil record, however, most of the major phyla appear fully formed at the beginning of the geological period known as the Cambrian, with no fossil evidence that they branched off from a common ancestor. Darwin was aware of this discrepancy, acknowledging in *The Origin of Species* that "several of the main divisions of the animal kingdom suddenly appear in the lowest known fossiliferous rocks." He called this a "serious" problem which "at present must remain inexplicable; and may be truly urged as a valid argument against the views here entertained" (*The Origin of Species*, Chapter X).

Darwin feared that the fossil record might by its very nature be so incomplete that a solution to the problem would never be found; but he hoped that future fossil-collecting might provide at least some evidence that animals shared a common ancestor. A century and a half later, however, the problem is more serious than ever. Paleontologists once thought that Precambrian animals might have been too small to be detected, but microscopic single-celled fossils much older than the Cambrian have since been discovered. Paleontologists also used to think that Precambrian animals might not have fossilized because they were soft-bodied, but it is now clear that most of the fossilized animals in the Cambrian explosion were soft-bodied. (See bibliography below.)

The geologically sudden appearance of the major animal phyla has become known as "the Cambrian explosion," or "Life's Big Bang," and many paleontologists consider it one of the most striking features of the fossil record. It has been the subject of recent articles in widely-read publications such as *Scientific American*, and in 1995 it was even on the cover of *Time* magazine. There is no excuse for a biology textbook to deal with the fossil record without even mentioning the Cambrian explosion. Furthermore, any biology textbook that fails to discuss the challenge posed by the Cambrian explosion to Darwin's theory would not enable students to "analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information" (Texas Education Code, § 31.023).

Cambrian Explosion Bibliography

Articles in scientific publications:

Simon Conway Morris & H. B. Whittington, "The Animals of the Burgess Shale," *Scientific American* 241 (July, 1979): 122-133.

J. William Schopf & Bonnie M. Packer, "Early Archean (3.3-Billion to 3.5-Billion-Year-Old) Microfossils from Warrawoona Group, Australia," *Science* 237 (1987): 70-73.

James W. Valentine, Stanley M. Awramik, Philip W. Signor and Peter M. Sadler, "The Biological Explosion at the Precambrian-Cambrian Boundary," *Evolutionary Biology* 25 (1991): 279-356.

Jeffrey S. Levinton, "The Big Bang of Animal Evolution," *Scientific American* 267 (November, 1992): 84-91.

Malcolm S. Gordon, "The Concept of Monophyly: A Speculative Essay," *Biology and Philosophy* 14 (1999): 331-348.

Robert L. Carroll, "Towards a new evolutionary synthesis," *Trends in Ecology and Evolution* 15 (2000): 27-32.

Articles in newspapers and magazines:

J. Madeleine Nash, "When Life Exploded," *Time* (December 4, 1995): 66-74.

Fred Heeren, "A Little Fish Challenges a Big Giant," *The Boston Globe* (May 30, 2000), p. E1.

Books:

Harry B. Whittington, *The Burgess Shale* (New Haven, CT: Yale University Press, 1985).

Stephen Jay Gould, *Wonderful Life* (New York: W. W. Norton, 1989).

Simon Conway Morris, *The Crucible of Creation* (Oxford: Oxford University Press, 1998).

TOPIC III
Vertebrate Embryos & Haeckel's Drawings

Darwin was aware of problems with the fossil record, including the Cambrian explosion, so he looked to embryology to provide the best evidence for his theory that all animals are descendants of a common ancestor. Darwin believed that the similarity of vertebrate embryos in their early stages reveals their common ancestry, and he considered those embryological similarities "by far the strongest single class of facts in favor of" his theory (*The Origin of Species,* Chapter XIV; Francis Darwin, ed., *The Life and Letters of Charles Darwin*, Vol. 2, p. 311).

Soon after the publication of *The Origin of Species*, German biologist Ernst Haeckel produced some drawings to illustrate Darwin's point by showing that vertebrate embryos are almost identical in their earliest stages. Some of Haeckel's peers, however, accused him of fraud for making the embryos appear much more similar than they really are. In fact, Haeckel's drawings misrepresent the evidence in three respects: They select from the wide variety of vertebrate embryos only those that come closest to fitting Darwin's theory, they distort those selected embryos to make them appear more similar than they really are, and they completely omit the embryos' earliest stages -- in which their dissimilarity is evident. (The early dissimilarity of vertebrate embryos does not support Darwin's theory, but must be explained away by the theory.) These distortions of the facts encouraged Haeckel and Darwin in their belief that vertebrates replay their evolutionary history ("phylogeny") during their embryo development ("ontogeny") -- a belief Haeckel immortalized with the phrase "ontogeny recapitulates phylogeny." Scientists now know that this doctrine is false.

Haeckel's fraud, originally exposed in Darwin's lifetime, is periodically re-discovered. In 1997, a team of embryologists compared Haeckel's drawings with photographs of real vertebrate embryos. In an interview with the journal *Science,* the leader of the team stated: "It looks like it's turning out to be one of the most famous fakes in biology." In 2000, Harvard evolutionary biologist Stephen Jay Gould wrote that Haeckel's drawings of vertebrate embryos "exaggerated the similarities by idealizations and omissions. He also, in some cases -- in a procedure that can only be called fraudulent -- simply copied the same figure over and over again." (See bibliography below.) Yet Haeckel's drawings, or redrawn versions of them, have been appearing in biology textbooks as evidence for evolution for over a century. There is no excuse for this. "We do, I think, have the right," Gould wrote in 2000, "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."

A few textbook authors have responded to criticisms by replacing Haeckel's drawings with photographs of actual vertebrate embryos. Even then, however, the selected embryos are usually the middle stages of chick and mammal embryos, which happen to resemble each other. Pictures of earlier stages, or the other vertebrate classes -- which do not exhibit an obvious resemblance to each other -- are omitted. Even though these textbooks are not recycling Haeckel's fraudulent drawings, they are still misleading students by

showing them only that part of the evidence that happens to fit Darwin's theory, and omitting evidence that the theory has difficulty explaining. Such textbooks cannot enable students to "analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information" (Texas Education Code, § 31.023).

Vertebrate Embryo Bibliography

Articles in scientific publications:

William W. Ballard, "Problems of gastrulation: real and verbal," *BioScience* 26 (1976): 36-39.

Guenter Rager, "Human embryology and the law of biogenesis," *Rivista di Biologia - Biology Forum* 79 (1986): 449-465.

M. K. Richardson, J. Hanken, M. L. Gooneratne, C. Pieau, A. Raynaud, L. Selwood, & G. M. Wright, "There is no highly conserved embryonic stage in the vertebrates: implications for current theories of evolution and development," *Anatomy & Embryology* 196 (1997): 91-106.

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

Jonathan Wells, "Haeckel's Embryos and Evolution: Setting the Record Straight," *The American Biology Teacher* 61 (May, 1999): 345-349.

Stephen Jay Gould, "Abscheulich! (Atrocious!)," *Natural History* (March, 2000): 42-49.

Articles in newspapers:

"Accused of Fraud, Haeckel Leaves the Church," *The New York Times*, November 27, 1910, Part V, p. 11.

Larry Witham, "Darwinism icons disputed," *The Washington Times* (National Weekly Edition), January 25-31, 1999, p. 28.

James Glanz, "Biology Text Illustrations More Fiction Than Fact," *The New York Times*, April 8, 2001, p. 18.

Book:

Jonathan Wells, *Icons of Evolution: Why much of what we teach about evolution is wrong* (Washington, DC: Regnery Publishing, 2000), chapter on "Haeckel's Embryos," pp. 81-109.

TOPIC IV
Peppered Moths

For the second part of his theory, "modification," Darwin relied principally on natural selection as the mechanism of evolution. Darwin himself had no direct evidence of natural selection, so he relied on examples from domestic breeding and "one or two imaginary illustrations" from nature (*The Origin of Species,* Chapter IV). It wasn't until a century after *The Origin of Species* that British physician Bernard Kettlewell claimed to have found "Darwin's missing evidence" in peppered moths.

Before the early 1800s, almost all peppered moths were light-colored. During the Industrial Revolution, however, moth populations shifted to being mostly dark-colored. According to evolutionary theory, the shift occurred because dark moths were better camouflaged against pollution-darkened tree trunks, and thus more likely to survive predatory birds. In the early 1950s, Kettlewell performed various experiments in which he released light and dark captive moths onto light and dark tree trunks, observed as birds ate the more conspicuous ones, and tallied the percentages of surviving moths the following day. His data seemed to support Darwin's theory. Peppered moths became the classical textbook story of natural selection in action, usually illustrated with photographs of light and dark moths on light and dark tree trunks.

In the 1960s, legislation reduced industrial pollution, and light moths made a comeback. Their comeback in many locations, however, preceded significant changes in the color of tree trunks, raising questions about the classical story. By the 1980s, it became clear that peppered moths don't normally rest on tree trunks. In several decades of field research, involving tens of thousands of moths, only 47 were found resting in the wild, and only six of those were found in exposed positions on tree trunks. The textbook photographs, it turns out, were staged -- in many cases by pinning or gluing dead moths to tree trunks.

In the 1950s, when experts still believed that peppered moths naturally rest on tree trunks, Kettlewell's experiments seemed valid and there was nothing wrong with staging photographs. But when it became clear that the basic premise of the classical story was false, textbooks should have started alerting students to the fact. The staged photographs should have been dropped, or at least properly labeled. Commercial enterprises are legally required to label their products and advertisements honestly; science textbooks should do no less.

The truth about the peppered moth story has been known for years (see the bibliography below). Articles in scientific journals and popular newspapers have been reporting on it since 1998, and the story was even the subject of a popular book in 2002. Last October, *The New York Times* included staged photographs of peppered moths in a gallery of famous examples of "scientific fakery." There is simply no excuse for textbook writers to continue misinforming students about the peppered moth story, much less accompanying the story with false and misleading photographs. Such textbooks cannot enable students to "analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information" (Texas Education Code, § 31.023).

Peppered Moth Bibliography

Articles in scientific publications:

Theodore D. Sargent, Craig D. Millar & David M. Lambert, "The 'Classical' Explanation of Industrial Melanism: Assessing the Evidence," *Evolutionary Biology* 30 (1998): 299-322.

Jerry Coyne, "Not black and white," a review of Michael Majerus's *Melanism: Evolution in Action*, *Nature* 396 (1998): 35-36.

Jonathan Wells, "Second Thoughts about Peppered Moths," *The Scientist*, May 24, 1999, p. 13.

Roy Herbert, "Fly by nights," *New Scientist*, September 21, 2002, p. 52.

Gabby Dover, "Mothbusters," *EMBO Reports* 4 (2003): 235.

Articles in newspapers:

Larry Witham, "Darwinism icons disputed," *The Washington Times* (National Weekly Edition), January 25-31, 1999, p. 28.

Nicholas Wade, "Staple of Evolutionary Teaching May Not Be Textbook Case," *The New York Times*, June 18, 2002, p. D1.

Geoffrey Norman, "A Flight From the Truth," *The Wall Street Journal*, August 20, 2002, p. D10.

Michael Kenney, "Evolution takes wings in Moths," *The Boston Globe*, August 20, 2002, p. C17.

Paul Raeburn, "'Of Moths and Men': The Moth That Failed," *The New York Times*, August 25, 2002, Section 7, p. 12.

Kenneth Chang, "On Scientific Fakery and the Systems to Catch It," *The New York Times*, October 15, 2002, p. D1.

Book:

Judith Hooper, *Of Moths and Men: An Evolutionary Tale* (New York: W.W. Norton, 2002).

LIST OF TEXTBOOKS

1
William K. Purves, David Sadava, Gordon H. Orians & H. Craig Heller
Life: The Science of Biology
6th edition
Sunderland, MA: Sinauer Associates
2001
ISBN 0-7167-3873-2

2
Peter H. Raven & George B. Johnson
Biology
6th edition
Boston, MA: McGraw-Hill
2002
ISBN 0-07-303120-8

3
Neil A. Campbell & Jane B. Reece
Biology
6th edition
San Francisco, CA: Benjamin Cummings
2002
ISBN 0-8053-6624-5

4
Biological Sciences Curriculum Study
BSCS Biology: An Ecological Approach
9th edition (BSCS Green Version)
Dubuque, IA: Kendall/Hunt
2002
ISBN 0-7872-7525-5

5
Biological Sciences Curriculum Study
BSCS Biology: A Human Approach
2nd edition
Dubuque, IA: Kendall/Hunt
2003
ISBN 0-7872-8685-0

6
Joseph Raver
Biology: Patterns and Processes of Life
1st edition
Dallas, TX: J.M. LeBel
2004
ISBN 0-920008-05-4

7
Sylvia S. Mader
Biology
8th edition
Boston, MA: McGraw-Hill
2004
ISBN 0-07-121487-9

8
Alton Biggs, Whitney Crispen Hagins, Chris Kapicka, Linda Lundgren, Peter Rillero, Kathleen G. Tallman, Dinah Zike & National Geographic Society
Biology: The Dynamics of Life
Texas Edition
New York, NY: McGraw-Hill
2004
ISBN 0-07-829904-7

9
George Johnson & Peter Raven
Holt Biology
Orlando, FL: Holt, Rinehart & Winston
2004
ISBN 0-03-068264-9

10
Kenneth R. Miller & Joseph Levine
Prentice Hall Biology
Texas edition
Upper Saddle River, NJ: Pearson Prentice Hall
2004
ISBN 0-13-115291-2

11
Cecie Starr & Ralph Taggart
Biology: The Unity and Diversity of Life
10th edition
Belmont, CA: Thomson
2004
ISBN 0-534-38801-9

Textbook 1

William K. Purves, David Sadava, Gordon H. Orians & H. Craig Heller
Life: The Science of Biology, 6th edition (2001)

TOPIC I: The 1953 Miller-Urey Experiment

a. The text includes a drawing of the Miller-Urey apparatus (on p. 452) accompanied by a misleading caption that gives students the impression that the 1953 experiment showed that "organic compounds [can] be generated under conditions similar to those that existed on the primeval Earth."

b. The textbook fails to inform students that the Earth's early atmosphere was probably quite different from the mixture of gases used in the experiment, or that when the experiment is repeated with a realistic mixture it does not work. Under realistic conditions, the molecules produced include toxic chemicals such as cyanide and formaldehyde but not amino acids.

c. The accompanying text completely omits any discussion of problems with the experiment, even though those problems have been widely reported in the scientific literature for several decades.

d. Because of its factual errors and lack of information, the text does not enable students to "analyze, review, and critique" this scientific explanation as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: F

TOPIC II: Darwin's Tree of Life & The Cambrian Explosion

a. This book briefly mentions the Cambrian explosion and explains that it marked the appearance of "all of the major groups of animals that have species living today" (on p. 387).

b. The book fails to point out, however, that Darwin considered this a serious problem for his theory and that the problem has not been solved. So the book does not enable students to "analyze, review, and critique" Darwin's theory that all animals are descended from a common ancestor as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: D

OVERALL GRADE: D -

Textbook 2

Peter H. Raven & George B. Johnson
Biology, 6th edition (2002)

TOPIC I: The 1953 Miller-Urey Experiment

a. Although this book includes a better-than-average discussion of the problems with the gas mixture used by Miller, its drawing of the Miller-Urey apparatus (on p. 64) is accompanied by a misleading caption that gives no indication of the problems with the experiment.

b. The text fails to inform students that when the experiment is repeated with a realistic gas mixture it doesn't work. The molecules produced under realistic conditions include toxic chemicals such as cyanide and formaldehyde but do not include amino acids.

c. Because of its misleading caption, factual errors and lack of information, the text does not enable students to "analyze, review, and critique" this scientific explanation as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: D

TOPIC II: Darwin's Tree of Life & The Cambrian Explosion

a. This book mentions the Cambrian explosion, explains that "almost all of the extant types of animals" appeared in it, and even includes a drawing of some of the Cambrian animals (on p. 472).

b. The book acknowledges that "what prompted this explosion of diversity is still a subject of considerable controversy" (p. 472), but it fails to point out why the Cambrian explosion poses a challenge to Darwin's theory. So the book does not adequately enable students to "analyze, review, and critique" Darwin's theory that all animals are descended from a common ancestor as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: C

TOPIC III: Vertebrate Embryos & Haeckel's Drawings

a. This book contains a modified version of Haeckel's drawings (on p. 450) that exaggerates actual similarities among fish, reptile, bird and human embryos.

b. The book's modified version of Haeckel's drawings omits earlier stages in which fish, reptile, bird and human embryos are much less similar.

c. The accompanying text misleadingly claims that "the evolutionary history of an organism can be seen to unfold during its development" (a form of Haeckel's discredited doctrine that "ontogeny recapitulates phylogeny").

d. The text falsely claims that "human embryos possess gill slits." (Human embryos never have gills, and calling features of human embryos "gill slits" is merely to read Darwinian theory into the evidence.)

e. Because of its factual errors and lack of information, the text does not enable students to "analyze, review, and critique" the embryological evidence for evolution as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: F

TOPIC IV: Peppered Moths

a. This book includes photographs of light- and dark-colored peppered moths on two different tree trunks (on p. 446), accompanied by a misleading caption that fails to notify students that the photographs were staged.

b. The lengthy account in the text retells the classical story. Although a student who reads all the way to the end of the account learns that scientists are now reconsidering the story and that "wherever the moths rest during the day, it does not appear to be on tree bark" (p. 447), such important information should be discussed in the body of the account and not merely tacked on as an afterthought.

Grade: D

OVERALL GRADE: D

Comments on the Book's Non-Scientific Contents:

Raven & Johnson's book contains the following passages:

"In the century since he proposed it, Darwin's theory of evolution by natural selection has become nearly universally accepted by biologists, but has proven controversial among some of the general public. Darwin's critics raise seven principal objections to teaching evolution:
…
3. The intelligent design argument. 'The organs of living creatures are too complex for a random process to have produced -- the existence of a clock is evidence of the existence of a clockmaker.' Biologists do not agree. The intermediates in the evolution of the mammalian ear can be seen in fossils, and many intermediate 'eyes' are known in various invertebrates. These intermediate forms arose because they have value -- being able to detect light a little is better than not being able to detect it at all. Complex structures like eyes evolved as a progression of slight improvements."
…
7. The irreducible complexity argument. 'The intricate molecular machinery of the cell cannot be explained by evolution from simpler stages. Because each part of a complex cellular process like blood clotting is essential to the overall process,

how can natural selection fashion any one part?' What's wrong with this argument is that each part of a complex molecular machine evolves as part of the system. Natural selection can act on a complex system because at every stage of its evolution, the system functions. Parts that improve function are added, and, because of later changes, become essential. The mammalian blood clotting system, for example, has evolved from much simpler systems. The core clotting system evolved at the dawn of the vertebrates 6000 million years ago, and is found today in lampreys, the most primitive fish. One hundred million years later, as vertebrates evolved, proteins were added to the clotting system making it sensitive to substances released from damaged tissues. Fifty million years later, a third component was added, triggering clotting by contact with the jagged surfaces produced by injury. At each stage as the clotting system evolved to become more complex, its overall performance came to depend on the added elements. Thus, blood clotting has become 'irreducibly complex' -- as a result of Darwinian evolution." (Raven & Johnson, p. 455)

"The objections raised by Darwin's critics are easily answered." (Raven & Johnson, p. 456)

These passages give the false impression that critics of Darwin's theory are not scientists, yet the most prominent advocate of the "irreducible complexity" criticism is a biochemist, Lehigh University Professor Michael J. Behe. Behe discusses the problem that the blood clotting cascade poses for Darwinian evolution in his book, *Darwin's Black Box: The Biochemical Challenge to Evolution* (New York: The Free Press, 1996). The over-simplified account of Behe's argument presented here is little more than a caricature, and it fails to answer Behe's objections to his critics. See Michael J. Behe, "In Defense of the Irreducibility of the Blood Clotting Cascade" at

http://www.discovery.org/viewDB/index.php3?program=CRSC%20Responses&command=view&id=442

Textbook 3

Neil A. Campbell & Jane B. Reece
Biology, 6th edition (2002)

TOPIC I: The 1953 Miller-Urey Experiment

a. This book includes a photo of Stanley Miller with his 1953 apparatus (on p. 53), accompanied by a misleading caption describing the experiment as "a laboratory simulation demonstrating that environmental conditions on the lifeless, primordial Earth allowed the spontaneous synthesis of some organic molecules." The experiment demonstrates no such thing, as the better-than-average account in the text acknowledges: Miller's simulated atmosphere "was probably more strongly reducing than the actual atmosphere of the early Earth. Modern volcanoes emit CO, CO_2, N_2, and water vapor, and it is likely that these gases were abundant in the ancient atmosphere. Hydrogen gas was probably not a major component." The caption is inconsistent with the rest of the text.

b. The book contains a drawing of the Miller-Urey apparatus (on p. 518), accompanied by a similarly misleading caption.

c. Although the text mentions the problems with Miller's simulated atmosphere, it fails to inform students that when the experiment is repeated with a realistic gas mixture it doesn't work. The molecules produced under realistic conditions include toxic chemicals such as cyanide and formaldehyde but do not include amino acids.

d. Because of its misleading caption, factual errors and lack of information, the text does not enable students to "analyze, review, and critique" this scientific explanation as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: D

TOPIC II: Darwin's Tree of Life & The Cambrian Explosion

a This book contains the fullest account of the Cambrian explosion (on pp. 642-644) of all the books reviewed here. It states that "most animal phyla originated in a relatively brief span of geologic time" (on p. 642, and it includes a drawing of representative Cambrian animals (on p. 643).

b. The book lists various hypotheses that attempt to explain the Cambrian explosion, but it acknowledges that the explosion remains "mysterious" (p. 644). Nevertheless ,the book fails to point out explicitly why the Cambrian explosion poses a challenge to Darwin's theory, so it does not adequately enable students to "analyze, review, and critique" Darwin's theory that all animals are descended from a common ancestor as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: C

OVERALL GRADE: C -

Textbook 4

Biological Sciences Curriculum Study
BSCS Biology: An Ecological Approach, 9th edition (Green Version, 2002)

TOPIC I: The 1953 Miller-Urey Experiment

a. This book includes a drawing of the Miller-Urey apparatus (on p. 267) accompanied by a misleading caption that gives the impression that "conditions thought to exist in the primitive atmosphere were reproduced in the laboratory."

b. The text fails to inform students that the Earth's early atmosphere was probably quite different from the mixture of gases used in the experiment.

c. The accompanying text vaguely concedes that "there are more questions about the origin of life than there are answers," but it fails to inform students about specific problems with the Miller-Urey experiment.

d. The text fails to state that when the experiment is repeated with a realistic mixture it does not work. The molecules produced under realistic conditions include toxic chemicals such as cyanide and formaldehyde but do not include amino acids.

e. Because of its factual errors and lack of information, the text does not enable students to "analyze, review, and critique" this scientific explanation as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: F

TOPIC II: Darwin's Tree of Life & The Cambrian Explosion

a. This book states that all major animal phyla "were represented in the Cambrian period" (on p. 564), but it fails to point out that they appeared suddenly in the Cambrian explosion.

b. Since the book fails even to mention the Cambrian explosion, much less discuss the challenge it poses to Darwin's theory, the book does not enable students to "analyze, review, and critique" the theory that all animals are descended from a common ancestor as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: F

TOPIC III: Vertebrate Embryos & Haeckel's Drawings

a. This textbook, unlike any others in this analysis, contains drawings that accurately reveal the dissimilarities in early vertebrate embryos (on p. 223).

b. Nevertheless, the text accompanying the drawings misleads students by stating: "As Figure 9.2 shows, for several vertebrates, the early stages of embryologic development are remarkably alike." In fact, during the earliest stages the embryos are remarkably dissimilar and only become alike midway

through development -- a pattern that does not fit the predictions of Darwin's theory.

c. Even though its embryo drawings are reasonably accurate, the text fails to discuss the fact that early vertebrate embryos display remarkable dissimilarities that are contrary to the predictions of evolutionary theory. Therefore the text does not enable students to "analyze, review, and critique" the embryological evidence for evolution as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: C

TOPIC IV: Peppered Moths

a. This book includes photographs of light- and dark-colored peppered moths on two different tree trunks (on p. 229), without informing students either that peppered moths do not normally rest on tree trunks or that the photographs have been staged.

b. The accompanying text fails to inform students about any of the problems with the classical peppered moth story.

c. Because of its factual errors and lack of information, the text does not enable students to "analyze, review, and critique" the classical peppered moth hypothesis as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: F

OVERALL GRADE: D -

Textbook 5

Biological Sciences Curriculum Study
BSCS Biology: A Human Approach, 2nd edition (2003)

TOPIC II: Darwin's Tree of Life & The Cambrian Explosion

a. Although this book includes sections titled "Modeling the Earth's History," "Evidence for Change across Time," and "Explaining Evolution," it does not mention the Cambrian explosion.

b. Since the book fails even to mention the Cambrian explosion, much less discuss the challenge it poses to Darwin's theory, the book does not enable students to "analyze, review, and critique" the theory that all animals are descended from a common ancestor as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: F

TOPIC III: Vertebrate Embryos & Haeckel's Drawings

This book contains no drawings of embryos, but mentions (on p. 46) that the teacher will provide students with "individual drawings of embryos." The accompanying study questions imply that the drawings will be used to support the standard claim that early similarities point to common ancestry.

Grade: X

OVERALL GRADE: F

NOTE: This book contains so little about evolution (it reads like a study guide keyed to other texts, rather than a textbook in its own right) that it is difficult to evaluate. Because of this, the book does not seem to fulfill the TEKS standards for teaching biology in general or biological evolution in particular.

Textbook 6

Joseph Raver
Biology: Patterns and Processes of Life, 1st edition (2004)

TOPIC I: The 1953 Miller-Urey Experiment

a. This book includes a drawing of the Miller-Urey apparatus (on p. 166) accompanied by an account in the text that completely misleads students about the experiment's significance. Among other things, the accompanying text falsely implies that when "common volcanic gases like carbon dioxide (CO_2), carbon monoxide (CO), [and] molecular nitrogen (N_2)" are used, the experiment still works. In fact, when the experiment is repeated with a realistic gas mixture it doesn't work. The molecules produced under realistic conditions include toxic chemicals such as cyanide and formaldehyde but do not include amino acids.

b. Because of its factual errors and lack of information, the text does not enable students to "analyze, review, and critique" this scientific explanation as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: F

TOPIC II: Darwin's Tree of Life & The Cambrian Explosion

a. This book mentions the Cambrian explosion (on p. 184) and correctly explains: "During a relatively brief time, perhaps as little as ten to twenty million years, most animal phyla existing today appeared in Earth's oceans" (p. 185).

b. The book states that "scientists disagree on underlying causes of the Cambrian explosion" (on p. 185), but it fails to points out the challenge that the Cambrian explosion poses to Darwin's theory. Thus the book does not enable students to "analyze, review, and critique" the theory that all animals are descended from a common ancestor as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: D

TOPIC III: Vertebrate Embryos & Haeckel's Drawings

a. This book contains a slightly simplified version of Haeckel's original fraudulent drawings of a fish, reptile, bird and human embryo (on p. 100). The accompanying caption falsely states: "All vertebrate embryos closely resemble one another in early development."

b. There is no indication in the text that the earlier stages of vertebrate embryos are actually quite different, or that early differences do not fit the pattern predicted by Darwin's theory.

c. Because of its factual errors and lack of information, the text does not enable students to "analyze, review, and critique" the embryological evidence for

evolution as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: F

TOPIC IV: Peppered Moths

a. This book includes photographs of light- and dark-colored peppered moths on two different tree trunks (on p. 112), without informing students either that peppered moths do not normally rest on tree trunks or that the photographs have been staged.

b. The accompanying text fails to inform students about any of the problems with the classical peppered moth story.

c. Because of its factual errors and lack of information, the text does not enable students to "analyze, review, and critique" the classical peppered moth hypothesis as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: F

OVERALL GRADE: F

Comments on the Book's Non-Scientific Contents:

According to the Texas Education Code, §28.002, Chapter 112, Subchapter C, §112.43, high school biology students are expected to "(C) evaluate the impact of research on scientific thought, society, and the environment," and "(F) research and describe the history of biology and contributions of scientists." Raver's book hampers students' ability to fulfill (F) because it systematically distorts the history of science, and it hampers students' ability to fulfill (C) because its historical distortions convey a false impression of the relationship between science and religion.

For example, in its discussion of classical belief in Creation, the book makes the following claims (on p. 99): "Until the 1500s, many Europeans believed Earth was flat and the sky was a large dome somehow suspended above it. Adventurous sailors like Columbus and Magellan, and the work of astronomers like Copernicus and Galileo, caused considerable controversy at the time…. [and] some scientists were executed for teaching that Earth and the other planets orbited the sun. Can you imagine living in a time when scientific curiosity was so discouraged or even forbidden?"

This passage contains two egregious falsehoods:

(1) It is not true that most Europeans in the 1500s believed in a flat Earth, or that Columbus caused controversy for believing that the Earth is round. Europeans inherited the ancient Greeks' knowledge not only of the Earth's shape, but also of its approximate circumference. Novelist Washington Irving's fictional 1828 account of how flat-earthers supposedly opposed Columbus was put forward as actual history by the late nineteenth-century anti-Christian authors John W. Draper and Andrew Dickson White, who used the flat Earth myth as a

way of discrediting Christians who challenged Darwinian evolution. See the book on this subject by University of California historian Jeffrey Burton Russell, *Inventing the Flat Earth* (New York: Praeger, 1997). See also James R. Moore, *The Post-Darwinian Controversies* (Cambridge: Cambridge University Press, 1979).

(2) It is not true that "some scientists were executed for teaching that Earth and the other planets orbited the sun." Giordano Bruno was executed by the Inquisition in 1600 for his heretical philosophical views and his zeal for religious reform; but although he happened to be a Copernican, his scientific views were not an issue. When Galileo attempted to convert the papal court to Copernicanism a few years later, Aristotelian scientists and philosophers prevailed upon the Church to silence him and place him under house arrest; but Galileo was never in danger of being executed for his Copernican beliefs. See Sir William Cecil Dampier, *A History of Science and its relations with Philosophy and Religion* (Cambridge: Cambridge University Press, 1977).

Furthermore, in its discussion of the decades immediately preceding the publication of Darwin's theory, Raver's book makes the following claim (on p. 102): "Especially daring scientists proposed an age [for the Earth] of more than a million years. This may sound silly to you, since you have probably grown up learning that many dinosaurs lived more than 100 million years ago, but it was an act of considerable courage during the eighteenth and nineteenth centuries to question the authority of religious institutions by proposing ideas contrary to religious teachings."

This passage misrepresents the history of geology and the nineteenth-century debates over the age of the Earth. When early geologists (who were for the most part devout Christians) found evidence that the Earth was very old, their findings were accepted without much fanfare, and by the time Darwin published *The Origin of Species* most educated Christians believed in an old Earth. The major opposition to Darwin's theory on chronological grounds came not from biblical fundamentalists but from physicists. See Charles Coulston Gillispie, *Genesis and Geology* (Cambridge, MA: Harvard University Press, 1951), and Peter J. Bowler, *Evolution: The History of an Idea,* revised edition (Berkeley: University of California Press, 1989).

In the context of this misrepresentation of history, Raver's statement that it "was an act of considerable courage during the eighteenth and nineteenth centuries to question the authority of religious institutions," like his false statements about opposition to Columbus from flat-earthers and executions of Copernican scientists, misleads students and tends to prejudice them against Christians. There is no justification for such statements in a science textbook.

Textbook 7

Sylvia S. Mader
Biology, 8th edition (2004)

TOPIC I: The 1953 Miller-Urey Experiment

a. This book includes a drawing of the Miller-Urey apparatus (on p. 320) accompanied by a caption that gives students no indication of the problems with the experiment.

b. The accompanying text leaves students with the false impression that experiments using more realistic, less-reducing gases produce similar results, and it misleads students by stating that these experiments "lend support to the hypothesis that the early Earth's atmospheric gases could have reacted with one another to produce small organic compounds." In fact, when the experiment is repeated with a realistic gas mixture it doesn't work. The molecules produced under realistic conditions include toxic chemicals such as cyanide and formaldehyde but do not include amino acids.

c. Although the text notes that "other investigators are concerned that Miller used ammonia as one of the atmospheric gases"(p. 321), it immediately dismisses the concern by speculating that ammonia might been abundant on the ocean floor.

d. Because of its factual errors and lack of information, the text does not enable students to "analyze, review, and critique" this scientific explanation as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: D

TOPIC II: Darwin's Tree of Life & The Cambrian Explosion

a. Although this book includes a section dealing with Cambrian animals (on p. 329), it omits any mention of the Cambrian explosion.

b. The book acknowledges that "all of today's groups of animals can trace their ancestry to this time [i.e., the Cambrian]" (on p. 329), but it leaves students with the impression that they had all evolved earlier. The book acknowledges that "no fossil evidence [of animals] occurs until the Cambrian" (on p. 329), and it attributes that to a lack of hard skeletal parts before the Cambrian, even though the preceding page (328) includes a description of soft-bodied Precambrian fossils.

c. Since the book fails even to mention the Cambrian explosion, much less discuss the challenge it poses to Darwin's theory, the book does not enable students to "analyze, review, and critique" the theory that all animals are descended from a common ancestor as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: F

TOPIC III: Vertebrate Embryos & Haeckel's Drawings

a. This book uses photographs of actual vertebrate embryos (on p. 296), instead of drawings. Nevertheless, the embryos shown are from two vertebrate classes (bird and mammal) whose embryos closely resemble each other at this stage; the other five vertebrate classes (which are much less similar) are omitted.

b. According to the accompanying caption, "at this comparable developmental stage, a chick embryo and a pig embryo have many features in common, which suggests they evolved from a common ancestor." Although this does not mislead students by claiming that the embryos shown are in their earliest stages, it fails to inform students that earlier stages are strikingly different, posing a problem for Darwin's belief that early similarity provides evidence for common ancestry.

c. Because of its factual errors and lack of information, the text does not enable students to "analyze, review, and critique" the embryological evidence for evolution as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: D

TOPIC IV: Peppered Moths

a. This book includes photographs of light- and dark-colored peppered moths on two different tree trunks (on p. 303), without informing students either that peppered moths do not normally rest on tree trunks or that the photographs have been staged.

b. The accompanying text fails to inform students about any of the problems with the classical peppered moth story.

c. Because of its factual errors and lack of information, the text does not enable students to "analyze, review, and critique" the classical peppered moth hypothesis as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: F

OVERALL GRADE: D -

Comments on the Book's Non-Scientific Contents:

This book states (on p. 300): "In California, the Institute for Creation Research advocates that students be taught an 'intelligent-design theory,' which says that DNA could never have arisen without the involvement of an 'intelligent agent,' and that gaps in the fossil record mean species arose fully developed with no antecedents. Since our country forbids the mingling of church and state -- that is, no purely religious idea can be taught in the schools -- the advocates for an intelligent-design theory are careful to never mention the Bible or ideas such

as 'God created the world in seven days.' Still, teachers who have a good scientific background do not feel comfortable teaching an intelligent-design theory because it does not meet the test of a scientific theory. Science is based on hypotheses that have been tested by observation and/or experimentation. A scientific theory has stood the test of time -- in other words, no hypotheses have been supported by observation and/or experimentation that runs counter to the theory. Indeed, the theory of evolution is supported by data collected in such wide-ranging fields as development, anatomy, geology, and biochemistry. The polls consistently show that nearly half of all Americans prefer to believe that the Old Testament account of how God created the world in seven days. That, of course, is their right, but should schools be required to teach an intelligent-design theory that traces its roots back to the Old Testament and is not supported by observation and experimentation?"

This passage contains numerous falsehoods and misleading statements. In fact, it is so one-sided that it seems more akin to indoctrination than education:

1. The Institute for Creation Research (ICR) does not advocate intelligent design theory. It advocates Young Earth Creationism, which is based on a literal reading of the Genesis account. The Institute for Creation Research actually criticizes intelligent design theory because it does not go far enough and is not based on the Biblical account of creation. (See, Henry M. Morris, "Design is not Enough!" Institute for Creation Research, July 1999, available at: http://www.icr.org.) It is therefore misleading and false to cite ICR in this context. If the author wishes to identify an organization favoring intelligent design it should be Discovery Institute, which is the major national research and policy organization advocating design theory.

2. The author unfairly and misleadingly implies that the real purpose of design theory is to defend a literal reading of Genesis. Contrary to the author's statements, the scientific theory of intelligent design is not derived from the Old Testament, nor is it a "purely religious idea." Unlike creationism, the scientific theory of intelligent design is agnostic regarding the source of design and has no commitment to defending Genesis, the Bible or any other sacred text. Instead, intelligent design theory is an effort to detect empirically whether the "apparent design" in nature observed by all biologists is genuine design (the product of an intelligent cause) or simply the product of chance and undirected natural laws. Intelligent design theory has intellectual roots in Aristotle and Plato, among many others, and it is derived from logical arguments and empirical evidence regarding design in nature. The modern theory of intelligent design was developed in the 1980s and 1990s, primarily by academics with backgrounds in biology, biochemistry, mathematics, and the history and philosophy of science.

3. The author asserts as fact that those "who have a good scientific background do not feel comfortable teaching an intelligent-design theory...." This falsely implies that those advocating intelligent design do not have good backgrounds in science. In fact, the major proponents of intelligent design theory are biologists, biochemists, mathematicians, physicists, and philosophers of science who have earned Ph.D.s in their respective fields, and many of them hold appointments at colleges and universities. Those scholars include biochemist Michael Behe at Lehigh University, mathematician William Dembski at Baylor University, quantum chemist Henry Schaeffer at the University of Georgia,

microbiologist Scott Minnich at the University of Idaho, and biologist Paul Chien at the University of San Francisco.

4. The author asserts as fact that intelligent design "does not meet the test of a scientific theory. Science is based on hypotheses that have been tested by observation and/or experimentation." The author adds at the end that intelligent design theory "is not supported by observation and experimentation...." This is a disputed opinion, not a fact. Scholars who are developing design theory (such as mathematician William Dembski at Baylor University) have proposed empirical methods by which to test whether the apparent design recognized by biologists in nature is in fact genuine design. Dembski outlined his proposed empirical test for design in a peer-reviewed monograph, *The Design Inference : Eliminating Chance through Small Probabilities*, published by Cambridge University Press as part of its Studies in Probability, Induction, and Decision series. In addition, scientists such as biochemist Michael Behe and microbiologist Scott Minnich have presented a wealth of detailed empirical data and observations in support of design theory. There is also now an international peer-reviewed academic journal devoted to design theory, *Progress in Complexity, Information, and Design*, with an editorial advisory board of more than 50 scholars from relevant scientific disciplines, most of whom have positions at universities or colleges.

5. The author falsely implies that it is unconstitutional to teach intelligent design theory in public schools. Many legal scholars in fact argue the opposite. See, for example, David DeWolf, Stephen Meyer, and Mark DeForrest, "Teaching the Origins Controversy: Science, Or Religion, Or Speech?" *Utah Law Review* (2000): 39-110; and Francis Beckwith, *Law, Darwinism & Public Education: The Establishment Clause and the Challenge of Intelligent Design* (Lanham, MD: Rowman and Littlefield, 2003).

The author of this passage shows no indication of even having read any of the standard books about intelligent design. Among those books are: Phillip E. Johnson, *Darwin On Trial* (Washington, DC: Regnery Publishing, 1991); Michael J. Behe, *Darwin's Black Box: The Biochemical Challenge to Evolution* (New York: The Free Press, 1996); William A. Dembski & James M. Kushiner (editors), *Signs of Intelligence: Understanding Intelligent Design* (Grand Rapids, MI: Brazos Press, 2001; William A. Dembski, *No Free Lunch: Why Specified Complexity Cannot Be Purchased without Intelligence* (Lanham, MD: Rowman & Littlefield Publishers, 2002).

By presenting the controversy over intelligent design in such an inaccurate and prejudicial way, Mader's book fails to prepare students to be informed participants in scientific and public-policy debates over evolution.

Textbook 8

Alton Biggs et al.
Biology: The Dynamics of Life, Texas Edition (2004)

TOPIC I: The 1953 Miller-Urey Experiment

a. This book includes a drawing of the Miller-Urey apparatus (on p. 382) accompanied by a misleading caption that claims "Miller and Urey's experiment showed that under the proposed conditions on early Earth, small organic molecules, such as amino acids, could form."

b. The accompanying text fails to inform students of the problems with the experiment.

c. Because of its factual errors and lack of information, the text does not enable students to "analyze, review, and critique" this scientific explanation as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: F

TOPIC II: Darwin's Tree of Life & The Cambrian Explosion

a. This book mentions the Cambrian explosion and explains that "the fossil record shows an enormous increase in the diversity of life forms during this time" (on p. 377).

b. The book fails to point out, however, that the Cambrian explosion poses a challenge to Darwin's theory. Thus the book does not enable students to "analyze, review, and critique" the theory that all animals are descended from a common ancestor as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: D

TOPIC III: Vertebrate Embryos & Haeckel's Drawings

a. This book contains a modified version of Haeckel's drawings (on p. 402) that exaggerates the similarities among fish, reptile, bird and human embryos.

b. The accompanying text misleadingly identifies these as "the earliest stage of growth and development" and claims that "it is the shared features in the young embryos that suggest evolution from a common ancestor." Yet the drawings omit earlier stages in which the embroys are much less similar.

c. There is no indication in the text that the earlier stages of vertebrate embryos are actually quite different, or that early differences do not fit the pattern predicted by Darwin's theory.

d. Because of its factual errors and lack of information, the text does not enable students to "analyze, review, and critique" the embryological evidence for

evolution as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: F

TOPIC IV: Peppered Moths

a. This book includes a photograph of light- and dark-colored peppered moths on a tree trunk (on p. 397), without informing students either that peppered moths do not normally rest on tree trunks or that the photograph has been staged.

b. The accompanying text fails to inform students about any of the problems with the classical peppered moth story.

c. Because of its factual errors and lack of information, the text does not enable students to "analyze, review, and critique" the classical peppered moth hypothesis as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: F

OVERALL GRADE: F

Textbook 9

George Johnson & Peter Raven
Holt Biology (2004)

TOPIC I: The 1953 Miller-Urey Experiment

a. This book contains a drawing of the Miller-Urey apparatus (on p. 254) accompanied by a misleading caption that states: "Miller simulated the early Earth's conditions."

b. The better-than-average account in the text points out that the Miller-Urey model is being re-evaluated because "we now know that the mixture of gases used in Miller's experiment could not have existed on the early Earth," and it informs students that when methane and ammonia "are absent the Miller-Urey experiment, key biological molecules are not made." Nevertheless, the text minimizes the problem by speculating that those molecules could have formed in bubbles in the ocean.

c. Because of its misleading caption and lack of sufficient information, the text does not enable students to "analyze, review, and critique" this scientific explanation as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: D

TOPIC II: Darwin's Tree of Life & The Cambrian Explosion

a. This book states that "most phyla that exist today probably originated during the Cambrian period" (on p. 262), but it does not explicitly mention the Cambrian explosion, or even that the animal phyla appeared relatively suddenly.

b. Since the book fails to mention the Cambrian explosion, much less discuss the challenge it poses to Darwin's theory, the book does not enable students to "analyze, review, and critique" the theory that all animals are descended from a common ancestor as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: F

OVERALL GRADE: D -

Textbook 10

Kenneth R. Miller & Joseph Levine
Prentice Hall Biology, Texas edition (2004)

TOPIC I: The 1953 Miller-Urey Experiment

a. This book contains a drawing of the Miller-Urey apparatus (on p. 424) accompanied by a misleading caption that states that the experiment "suggested how simply compounds found on the early Earth could have combined to form the organic compounds needed for life."

b. The account in the text points out that "scientists now know that Miller and Urey's original simulations of Earth's early atmosphere were not accurate," but it goes on to claim that "similar experiments based on more accurate knowledge of Earth's early atmosphere have also produced organic compounds" -- without pointing out that those compounds included toxic chemicals such as cyanide and formaldehyde but did not include amino acids.

c. A study guide at the end of the chapter misinforms students that "Miller and Urey's experiments suggested how mixtures of the organic compounds necessary for life could have arisen from simpler compounds present on the primitive Earth" (p. 442).

d. Because of its misleading caption and study guide, its factual errors and its lack of information, the text does not enable students to "analyze, review, and critique" this scientific explanation as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: D

TOPIC II: Darwin's Tree of Life & The Cambrian Explosion

a. This book mentions the Cambrian explosion and explains that "during the Cambrian period, the first known representatives of most animal phyla evolved" (on p. 430).

b. The book does not explain, however, why the Cambrian explosion poses a challenge to Darwin's theory. Thus the book the book does not enable students to "analyze, review, and critique" the theory that all animals are descended from a common ancestor as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: D

TOPIC III: Vertebrate Embryos & Haeckel's Drawings

a. This book uses photographs of actual vertebrate embryos (on p. 385), instead of drawings. Nevertheless, the embryos shown are from the three vertebrate classes (bird, reptile and mammal) whose embryos most resemble each other; the other four vertebrate classes are omitted.

b. The accompanying caption misleadingly states: "In their early stages of development, chickens, turtles, and rats look similar, providing evidence that they shared a common ancestor." In fact, the photographs show embryos midway through development instead of at their earliest stages.

c. The accompanying text informs students that "Haeckel fudged some of his drawings to make the earliest stages of embryos seem more similar than they actually are," but it fails to inform students that Haeckel's "earliest stages" were actual midway through development. In fact, vertebrate embryos in their earliest stages are strikingly different, and their differences do not fit the pattern predicted by Darwin's theory.

d. Because of its factual errors and lack of information, the text does not enable students to "analyze, review, and critique" the embryological evidence for evolution as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: D

OVERALL GRADE: D

Textbook 11

Cecie Starr & Ralph Taggart
Biology: The Unity and Diversity of Life, 10th edition (2004)

TOPIC I: The 1953 Miller-Urey Experiment

a. This book includes a drawing of the Miller-Urey apparatus (on p. 329) accompanied by a misleading caption that claims Miller studied "the synthesis of organic compounds under conditions that presumably existed on the early Earth."

b. The accompanying text fails to inform students that the Earth's early atmosphere was probably quite different from the mixture of gases used in the experiment, or that when the experiment is repeated with a realistic mixture it does not work. Under realistic conditions, the molecules produced include toxic chemicals such as cyanide and formaldehyde but not amino acids.

c. The text completely omits any discussion of problems with the experiment, even though those problems have been widely reported in the scientific literature for several decades.

d. Because of its factual errors and lack of information, the text does not enable students to "analyze, review, and critique" this scientific explanation as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: F

TOPIC II: Darwin's Tree of Life & The Cambrian Explosion

a. This book uses the term "Cambrian explosion" but states as a fact the hypothesis that "most major animal phyla had evolved earlier in the Precambrian seas" (on p. 336). So the book glosses over the Cambrian explosion instead of describing it accurately.

b. Since the book fails to describe the Cambrian explosion, much less discuss the challenge it poses to Darwin's theory, the book does not enable students to "analyze, review, and critique" the theory that all animals are descended from a common ancestor as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: D

TOPIC III: Vertebrate Embryos & Haeckel's Drawings

a. This book contains a slightly simplified version of Haeckel's original fraudulent drawings of a fish, reptile, bird and human embryo (on p. 315). The accompanying caption falsely states: "Adult vertebrates are diverse, yet their embryos are quite similar at very early stages. Diversity arises as embryos start developing differently at later stages."

b. There is no indication in the text that the earlier stages of vertebrate embryos are actually quite different, or that early differences do not fit the pattern predicted by Darwin's theory.

c. Because of its factual errors and lack of information, the text does not enable students to "analyze, review, and critique" the embryological evidence for evolution as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: F

TOPIC IV: Peppered Moths

a. This book includes photographs of light- and dark-colored peppered moths on various tree trunks (on pp. 10 and 283), without informing students either that peppered moths do not normally rest on tree trunks or that the photographs have been staged.

b. The accompanying text fails to inform students about any of the problems with the classical peppered moth story.

c. Because of its factual errors and lack of information, the text does not enable students to "analyze, review, and critique" the classical peppered moth hypothesis as to its "strengths and weaknesses using scientific evidence and information" (TEKS §112.43c(3)A).

Grade: F

OVERALL GRADE: F

Comments on the Book's Non-Scientific Contents:

According to the Texas Education Code, §28.002, Chapter 112, Subchapter C, §112.43, high school biology students are expected to "(C) evaluate the impact of research on scientific thought, society, and the environment," and "(F) research and describe the history of biology and contributions of scientists." Starr & Taggart's book hampers students' ability to fulfill (F) because it distorts the history of science, and it hampers students' ability to fulfill (C) because its distorted history conveys a false impression of the relationship between science and religion.

This book states (on p. 15): "Centuries ago in Europe, Nicolaus Copernicus studied the planets and concluded the Earth circles the sun. Today this seems obvious enough. Back then, it as heresy. The prevailing belief was that the Creator made the Earth -- and, by extension, humans -- the immovable center of the universe. Later a respected scholar, Galileo Galilei, studied the Copernican model of the solar system, though it was a good one, and said so. He was forced to retract his statement publicly, on his knees, and put the Earth back as the fixed center of things. (Word has it that when he stood up he muttered, 'Even so, it does move.') Later still, Darwin's theory of evolution ran up against the same prevailing belief."

This over-simplified account of the Galileo affair makes it sound as though Galileo's principal conflict was with the Church, when it was actually with the Aristotelian scientists of his day. See Sir William Cecil Dampier, *A History of Science and its relations with Philosophy and Religion* (Cambridge: Cambridge University Press, 1977). By conflating the Galileo affair with the Darwinian controversies, Starr & Taggart also give students the false impression that the primary opposition to Darwin came from religion. In reality, Darwin provoked at least as much controversy among scientists as among theologians, and many of the latter actually sided with him. See James R. Moore, *The Post-Darwinian Controversies* (Cambridge: Cambridge University Press, 1979); Peter J. Bowler, *Evolution: The History of an Idea,* revised edition (Berkeley: University of California Press, 1989).

This passage misinforms students about the historical relations between science and religion and encourages them to regard religion as the enemy of science. The book thus fails to enable students to evaluate accurately the impact of science on society.

SUMMARY

Each textbook is graded based on the five topics.

	1	2	3	4	5	6	7	8	9	10	11
I	**F**	**D**	**D**	**F**	**n/a**	**F**	**D**	**F**	**D**	**D**	**F**
II	**D**	**C**	**C**	**F**	**F**	**D**	**F**	**D**	**F**	**D**	**D**
III	**n/a**	**F**	**n/a**	**C**	**X**	**F**	**D**	**F**	**n/a**	**D**	**F**
IV	**n/a**	**D**	**n/a**	**F**	**n/a**	**F**	**F**	**F**	**n/a**	**n/a**	**F**
total	**D-**	**D**	**C-**	**D-**	**F**	**F**	**D-**	**F**	**D-**	**D**	**F**

Textbooks:

1 Purves et al.
2 Raven & Johnson
3 Campbell & Reece
4 BSCS Ecological
5 BSCS Human
6 Raver
7 Mader
8 Biggs et al.
9 Johnson & Raven
10 Miller & Levine
11 Starr & Taggart

Topics:

I Miller-Urey Experiment
II Tree of life & Cambrian explosion
III Vertebrate embryos
IV Peppered moths

Note on Grades:

X = book contains misleading information, but no illustration
n/a = book does not contain this topic

THE BEST TEXTBOOK: Campbell & Reece

THE WORST TEXTBOOKS: The following books contain material that is so factually misleading, and that ignores the scientific literature so completely, that unless they are substantially revised they may be totally unsuitable for use in biology classrooms:

TEXTBOOK	MISLEADING MATERIAL(S)
Purves et al.	Miller-Urey
Raven & Johnson	Vertebrate embryos
BSCS (Ecological)	Miller-Urey, Cambrian explosion, Peppered moths
BSCS (Human)	Cambrian explosion
Raver	Miller-Urey, Vertebrate embryos, Peppered moths
Mader	Cambrian explosion, Peppered moths
Johnson & Raven	Cambrian explosion
Biggs et al.	Miller-Urey, Vertebrate embryos, Peppered moths
Starr & Taggart	Miller-Urey, Vertebrate embryos, Peppered moths

NOTES:

The BSCS Human Approach book contains so little about evolution (it reads like a study guide keyed to other texts) that it is difficult to evaluate.

The Raver book, in addition to containing three egregious examples of misleading materials, also contains three blatantly false historical claims that discriminate against Christians.

APPENDIX

Criteria for Grading Textbooks on Specific Topics

The following criteria are from "An Evaluation of Ten Recent Biology Textbooks," in Jonathan Wells, *Icons of Evolution: Why much of what we teach about evolution is wrong* (Washington, DC: Regnery Publishing, 2000), pp. 249-258.

In general, an "A" requires full disclosure of the truth, discussion of relevant scientific controversies, and a recognition that Darwin's theory -- like all scientific theories -- might have to be revised or discarded if it doesn't fit the facts. An "F" indicates that the textbook uncritically relies on logical fallacy, dogmatically treats a theory as an unquestionable fact, or blatantly misrepresents published scientific evidence.

TOPIC I: The Miller-Urey Experiment

A = does not include a picture or drawing of the Miller-Urey apparatus, or else accompanies it with a caption pointing out that the experiment (though historically interesting) is probably irrelevant to the origin of life because it did not simulate conditions on the early Earth; text mentions the controversy over oxygen in the primitive atmosphere, and includes extensive discussion of the other problems faced by origin-of-life research, acknowledging that they remain intractable.

B = does not include a picture or drawing of the Miller-Urey apparatus, or else accompanies it with a caption pointing out that the experiment (though historically interesting) is probably irrelevant to the origin of life because it did not simulate conditions on the early Earth; text includes at least some discussion of other problems in origin-of-life research, and does not leave the student with the impression that scientists are on the verge of understanding the origin of life.

C = includes a picture or drawing of the Miller-Urey apparatus, but the caption does not claim that the Miller-Urey experiment simulated conditions on the early Earth; the accompanying text points out that the experiment fails even if other starting mixtures are used, and does not leave the student with the impression that the experiment (or some variant of it) demonstrated how life's building-blocks formed on the early earth; does not discuss other problems with origin-of-life research.

D = includes a picture or drawing of the Miller-Urey apparatus with a misleading caption claiming or implying that the experiment simulated conditions on the early Earth; but the accompanying text explicitly points out that this was probably not the case (merely listing other gasses, and leaving it to the student to spot the discrepancy, is not sufficient); may leave the student with

the impression that the experiment (or some variant of it) demonstrated how life's building-blocks formed on the early earth.

F = includes a picture or drawing of the Miller-Urey apparatus with a misleading caption claiming or implying that the experiment simulated conditions on the early Earth; the text contains no mention of the experiment's flaws, and leaves the student with the impression that it demonstrated how life's building-blocks formed on the early earth.

TOPIC II: Darwin's Tree of Life & The Cambrian Explosion

A = explicitly treats universal common ancestry as a theory rather than a fact; clearly points out that the "top-down" Cambrian explosion contradicts the "bottom-up" pattern of Darwinian evolution, and acknowledges the theoretical possibility of multiple origins and separate lines of descent; also mentions problems for universal common ancestry posed by recent evidence from molecular phylogeny.

B = explicitly treats universal common ancestry as a theory rather than a fact; clearly points out that the "top-down" Cambrian explosion contradicts the "bottom-up" pattern of Darwinian evolution, and acknowledges the theoretical possibility of multiple origins and separate lines of descent; but does not mention recent problems in molecular phylogeny.

C = explicitly treats universal common ancestry as a theory rather than a fact; discusses the Cambrian explosion as a problem for Darwinian evolution, but does not mention the theoretical possibility of multiple origins and separate lines of descent.

D = assumes the truth of universal common ancestry without questioning it (and may call it a "fact"); mentions the Cambrian explosion in the body of the text (briefly mentioning it in a note at the end of the chapter, without explaining what it is, is not sufficient), but does not discuss the problem it poses for Darwinian evolution.

F = assumes the truth of universal common ancestry without questioning it (and may call it a "fact"); does not even mention the Cambrian explosion.

TOPIC III: Vertebrate Embryos & Haeckel's Drawings

A = does not use misleading drawings or photos, and does not call pharyngeal pouches "gill slits"; points out that vertebrate embryos are most similar midway through development, after being dissimilar in their earliest stages; acknowledges this as an unresolved problem for Darwinian evolution, and considers the possibility that Darwin's theory of vertebrate origins could be wrong.

B = does not use misleading drawings or photos, and does not call pharyngeal pouches "gill slits"; points out that vertebrate embryos are most similar midway through development, after being dissimilar in their earliest stages; acknowledges this as an unresolved problem for Darwinian evolution, but does not explicitly consider the possibility that Darwin's theory of vertebrate origins could be wrong.

C = does not use misleading drawings or photos; points out that vertebrate embryos are most similar midway through development, after being dissimilar in their earliest stages, but explains away this fact in order to reconcile it with Darwinian evolution; may call pharyngeal pouches "gill slits."

D = uses actual photos rather than Haeckel's drawings, but chooses those which best fit the theory; fails to mention that earlier stages are dissimilar, and claims that early similarities in vertebrate embryos are evidence for common ancestry and Darwinian evolution; may call pharyngeal pouches "gill slits."

F = uses Haeckel's drawings (or a re-drawn version of them) without mentioning the dissimilarity of earlier stages; claims that early similarities in vertebrate embryos are evidence for common ancestry and Darwinian evolution; may call pharyngeal pouches "gill slits."

TOPIC IV: Peppered Moths

A = uses photos of moths in their natural resting places; does not use staged photos of moths on tree trunks (except as illustrations of how the classical story was wrong); clearly discusses unresolved problems with Kettlewell's experiments and the classical story, and points out that these problems raise serious doubts about whether peppered moths provide direct evidence for natural selection.

B = uses photos of moths in their natural resting places; does not use staged photos of moths on tree trunks (except as illustrations of how the classical story was wrong); mentions unresolved problems with Kettlewell's experiments and the classical story, but does not discuss the possibility that peppered moths do not provide direct evidence for natural selection.

C = uses staged photos but clearly explains that they were staged, because moths do not rest on tree trunks in the wild; describes Kettlewell's experiments, but briefly mentions that they and the classical story are now in doubt.

D = uses staged photos without mentioning that they misrepresent the natural situation; but the accompanying text at least hints at the fact that there are problems with Kettlewell's experiments or the classical story.

F = uses staged photos without mentioning that they misrepresent the natural situation; describes Kettlewell's experiments as a demonstration of natural selection, without mentioning their flaws or problems with the classical story.