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# **Not Making the Grade: An Evaluation of 22 Recent Biology Textbooks And Their Use of Selected Icons of Evolution**

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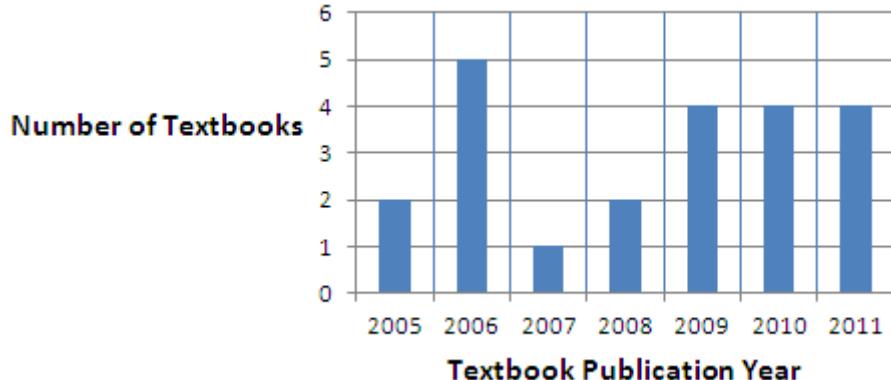
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## **I. Executive Summary**

In 2000, Jonathan Wells published a review of biology textbooks in their treatment of the “icons” of evolution.<sup>i</sup> Wells applied criteria to 10 then-current biology textbooks in their coverage of common lines of evidence used to support evolution.

This updated 2011 textbook review applies Wells' evaluation criteria of the icons to 22 recent biology textbooks, all published since 2005. The average publication year of the 22 textbooks analyzed is 2008; the distribution of publication years of the textbooks analyzed is seen in the Figure 1 below.

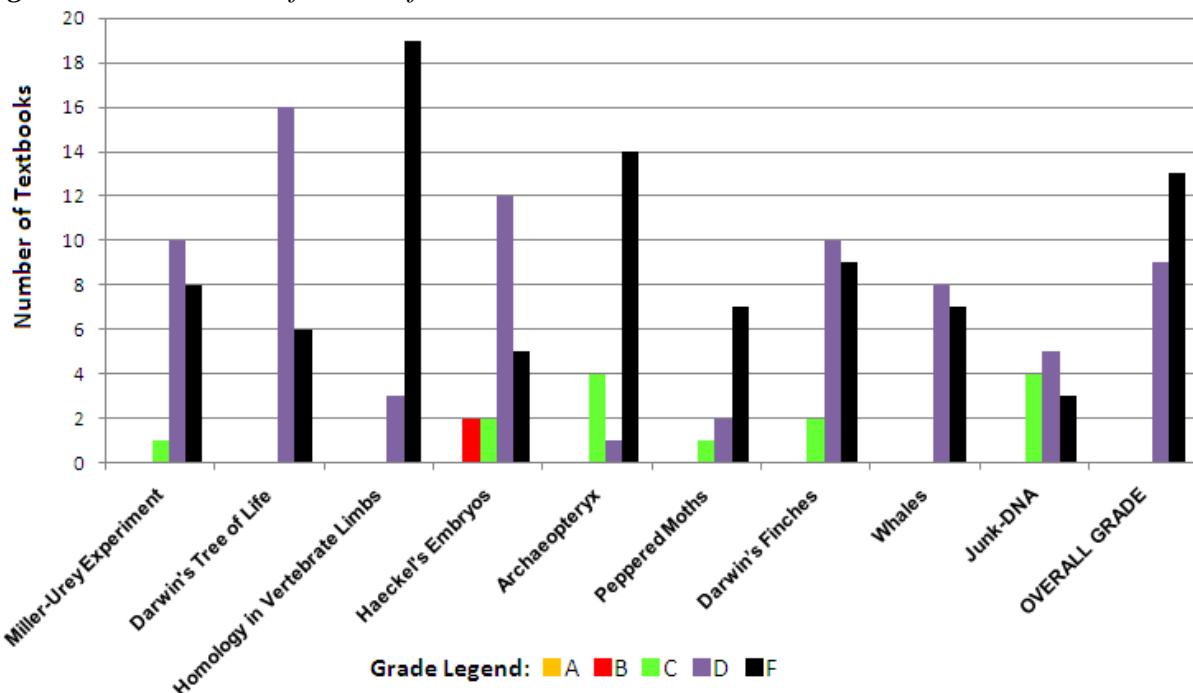
**Figure 1: Distribution of Publication Years of Textbooks Evaluated in Current Evaluation.**



This 2011 textbook evaluation also adds two new icons which have grown in popularity over the past decade. A series of fossils purportedly showing the evolution of whales from land mammals is now printed uncritically in many biology textbooks as an alleged “poster child” for macroevolution. Another new icon is “junk” DNA, where some textbooks claim that noncoding DNA is functionless junk.

This review thus evaluates nine icons in 22 total textbooks. A summary of the overall grade distribution for each icon is seen in Figure 2 below.

**Figure 2: Distribution of Grades for Each Icon Evaluated in 2011 Textbook Review.**

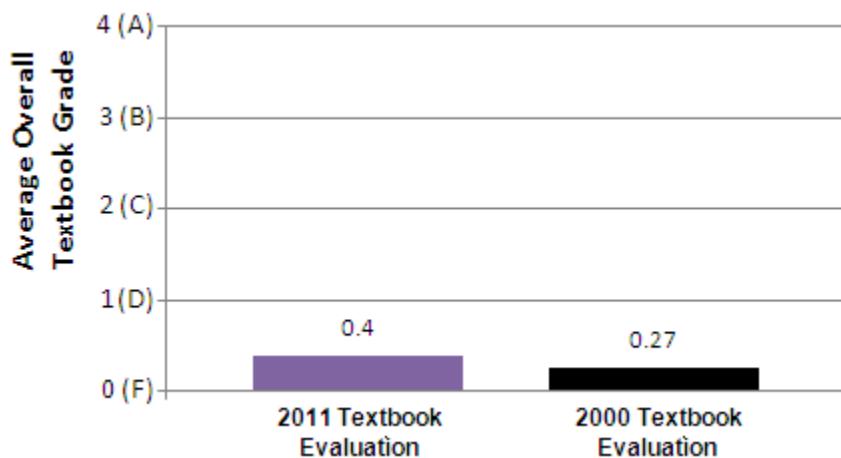


As will be discussed further in Section VII, the textbooks assessed in this review show little overall improvement since Wells' review in 2000. The one icon that showed nontrivial

improvement was Haeckel's embryos. This is largely because many textbooks no longer use drawings of embryos, and instead use photographs. The improvement most likely reflects increased public awareness about inaccuracies in embryo drawings that resulted from the work of Dr. Wells in his 2000 book *Icons of Evolution* and subsequent publicity on this issue. Despite this improvement, the average grade for Haeckel's embryos remains a D, as most textbooks still overstate vertebrate embryo similarities. In fact, this current view finds that there are still textbooks, including a 2010 textbook and a 2011 textbook, that use embryo diagrams directly taken from Haeckel's inaccurate drawings. The tree of life icon also showed very slight improvement, largely because more textbooks now mention the Cambrian explosion.

**The overall average textbook grade of this 2011 review is an F (0.4 on 4-point GPA scale), compared to a 0.27 average GPA (also an F) in the 2000 review.** In that regard, while there is extremely slight improvement in the average overall textbook grade between the 2000 and 2011 textbook reviews, current biology textbooks remain grossly inaccurate and biased when presenting the evidence regarding neo-Darwinian evolution. Textbook treatment of the icons of evolution is far below an acceptable level. The figure below compares the overall average textbook grades of the 2011 review with the overall average grade of the 2000 textbook review.

**Figure 3: Average Overall Textbook Grade (on 4-point GPA Scale) of 2011 and 2000 Textbook Reviews.**



**The overall finding of this review is that textbook treatment of the icons of evolution has not meaningfully improved since Wells' 2000 review. No textbook in this review received an overall grade higher than D+. No icon received an average grade greater than a D. The average overall textbook grade in this review is an F. Current biology textbooks continue to promote evolution in an inaccurate and biased pro-Darwin-only fashion.**

## II. Textbook Grades

**Table 1:** Grades of Nine Icons of Evolution in 22 Current Biology Textbooks

Icon: Textbook	Miller-Urey Experiment	Darwin's Tree of Life	Vertebrate Limb Homology	Haedekel's Embryos	Archaeopteryx	Peppered Moths	Darwin's Finches	Whales	Junk-DNA	Overall Grade
1.	F	D	F	D	N/A	N/A	D-	N/A	N/A	F
2.	F	D	F	D+	C	F	D	N/A	N/A	D-
3.	N/A	F	F	F	N/A	N/A	F	D-	N/A	F
4.	F	F	D	C	F	F	F	N/A	F	F
5.	D-	D-	D-	B	N/A	D-	D	N/A	N/A	D+
6.	D	D+	F	D	F	N/A	D	F	C	D
7.	F	D	F	D	F	N/A	C	D-	F	F
8.	F	D	F	N/A	C-	F	D	D-	D+	D-
9.	C	D	F	D	F	C	D	D-	F	D-
10.	N/A	D	F	D	F	F	F	F	N/A	F
11.	D	D	F	F	F	F	F	F	C-	F
12.	F	F	F	F	F	N/A	F	C	F	
13.	D-	D	D	D+	C	N/A	F	N/A	D+	D
14.	D	D	F	C-	F	N/A	F	F	N/A	F
15.	F	F	F	F	F	N/A	D	N/A	N/A	F
16.	N/A	F	F	D	F	N/A	D	D	N/A	F
17.	D	F	F	D	D-	N/A	F	D-	D+	F
18.	D-	D	F	F	F	D	D	D-	C-	D-
19.	D	D	F	D	F	N/A	F	D-	D+	F
20.	F	D	F	B	F	N/A	D+	N/A	D	D
21.	D	D	F	D	C	N/A	C	F	D	D
22.	D	D+	F	D	F	F	F	F	N/A	F

### **III. List of Textbooks Evaluated**

1. Colleen Belk and Virginia Borden Maier, *Biology: Science for Life* (Benjamin Cummings, 3<sup>rd</sup> ed., 2010).
2. Alton Biggs, Whitney Crispen Hagins, Chris Kapicka, Linda Lundgren, Peter Rillero, Kathleen G. Tallman, Dinah Zike *Biology: The Dynamics of Life* (Glencoe, 2006) (Florida Edition).
3. *BSCS Biology: A Human Approach* (Kendall Hunt Publishing Company, 2006).
4. *BSCS Biology: A Molecular Approach* (Glencoe/McGraw Hill, 2006).
5. *BSCS Biology: An Ecological Approach* (10<sup>th</sup> ed., Kendall Hunt Publishing Company, 2006).
6. Neil A. Campbell, Jane B. Reece, Martha R. Taylor, Eric J. Simon, Jean L. Dickey, *Biology: Concepts and Connections* (6<sup>th</sup> Ed., Pearson, 2009).
7. Scott Freeman, *Biological Science* (4<sup>th</sup> ed., Benjamin Cummings / Pearson, 2011).
8. Douglas J. Futuyma, *Evolution* (Sinauer, 2005)
9. George B. Johnson, *Essentials of the Living World* (McGraw Hill, 2006).
10. Sylvia S. Mader, *Essentials of Biology* (McGraw Hill, 2007).
11. Sylvia S. Mader, *Biology* (10<sup>th</sup> ed., McGraw Hill 2010).
12. Sylvia S. Mader, Jeffrey A. Isaacson, Kimberly G. Lyle-Ippolito, Andrew T. Storfer, *Inquiry Into Life* (13<sup>th</sup> ed., McGraw Hill, 2011).
13. Kenneth R. Miller and Joseph Levine, *Biology* (Prentice Hall, 2008) (Teacher's Edition).
14. Kenneth R. Miller and Joseph Levine, *Biology* (Pearson, 2010).
15. National Geographic, Alton Biggs, Lucy Daniel, Edward Ortley, Peter Rillero, Dinah Zike, *Life Science* (McGraw Hill / Glencoe, 2005).
16. Michael J. Padilla, Ioannis Miaoulis, Martha Cyr, *Science Explorer: Life Science* (Prentice Hall, 2009).
17. John H. Postlethwait and Janet L. Hopson, *Modern Biology* (Holt, Rinehart and Winston, 2009).
18. Peter H. Raven, George B. Johnson, Kenneth A. Mason, Jonathan B. Losos, and Susan R. Singer, *Biology*, (9<sup>th</sup> ed., McGraw Hill, 2011).
19. Jane B. Reece, Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, Robert B. Jackson, *Campbell Biology* (9<sup>th</sup> ed. Benjamin Cummings, 2011).

20. David Savada, H. Craig Heller, Gordon H. Orians, William K. Purves, David M. Hillis, *Life: The Science of Biology* (8<sup>th</sup> ed., Sinauer Associates, 2008).
21. Eric J. Simon, Jane B. Reece, Jean L. Dickey, *Campbell Essential Biology* (4<sup>th</sup> ed., Benjamin Cummings, 2010).
22. Cecie Starr, Ralph Taggart, Christine Evers, Lisa Starr, *Biology: The Unity and Diversity of Life* (12<sup>th</sup> ed., Brooks/Cole, 2009).

## **IV. Evaluation Criteria**

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. N/A indicates the textbook either did not contain the icon or did not contain enough information to evaluate the icon. Documentation for the grade for each individual icon in each textbook is found in an endnote.

Overall grades were calculated using standard GPA calculation methods on a 4-point scale, using the following values for grades: A+ = 4.3; A = 4.0; A- = 3.7; B+ = 3.3; B = 3.0; B- = 2.7; C+ = 2.3; C = 2.0; C- = 1.7; D+ = 1.3; D = 1.0; D- = 0.7; F = 0.

## **V. Icons of Evolution Explained**

### **1. The Miller-Urey Experiment**

Many modern scientists believe that living cells arose from chemical building-blocks that formed on the early Earth. In 1953, Stanley Miller used an electric spark to simulate lightning in a mixture of gasses thought to resemble the Earth’s primitive atmosphere, and produced some of the chemical building-blocks of life. The experiment is pictured in many biology textbooks to show that scientists now understand an important early step in the origin of life, but scientists determined years ago that the Earth’s primitive atmosphere was probably nothing like the mixture of gasses Miller used. Most now acknowledge that the origin of life’s building-blocks remains unexplained.<sup>ii</sup>

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.

## 2. Darwin's Tree of Life

Darwin believed that all living things are modified descendants of one or a few original forms. Most biology textbooks show the branching-tree pattern that would result from such "descent with modification" and tell students that it is so thoroughly confirmed by the fossil and molecular evidence that it may be called a "scientific fact." But the fossil record of the Cambrian explosion shows that the major groups of animals appeared at about the same time — a "lawn" rather than a tree; and recent molecular evidence suggests a "tangled thicket" instead of the branching pattern of Darwin's tree of life.<sup>iii</sup>

A = explicitly treats universal common ancestry as a hypothesis rather than an established 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 hypothesis rather than an established 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; mentions assumptions in tree-building but does not mention recent problems in molecular phylogeny.

C = explicitly treats universal common ancestry as a hypothesis 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.

### 3. Homology in Vertebrate Limbs

A bat’s wing, a porpoise’s flipper, a horse’s leg, and a human hand all contain bones that are structurally similar. Before Darwin, biologists called this “homology,” and considered it evidence for a common design, but Darwin attributed it to a common ancestor. Modern Darwinists have re-defined homology as similarity due to common ancestry, but now homology cannot serve as evidence for common ancestry without arguing in a circle. Many biology textbooks use circular reasoning anyway, as if to say, “We know that two features are homologous because they come from a common ancestor, and we know they come from a common ancestor because they’re homologous.”<sup>iv</sup>

A = defines homology as similarity of structure and position, and explains that this was historically attributed to a common archetype; mentions a biological ancestor as one possible meaning of “archetype” but acknowledges that there are others and that the concept of homology continues to be controversial; clearly explains that the two biological mechanisms proposed so far to account for homology (similar genes and similar developmental pathways) are inconsistent with the evidence.

B = defines homology as similarity of structure and position due to a common archetype and identifies “archetype” with a biological ancestor without explaining that there are other possibilities; points out that the two biological mechanisms proposed so far to account for this (similar genes and similar developmental pathways) are inconsistent with the evidence.

C = defines homology as similarity of structure and position and cites it as evidence for common ancestry; attributes homology to similar genes or similar developmental pathways but at least hints that there are problems with the evidence.

D = defines homology as similarity of structure and position and cites it as evidence for common ancestry; may attribute homology to similar genes or similar developmental pathways but fails to mention that the evidence does not fit the claim.

F = defines homology as similarity due to common ancestry, then engages in circular reasoning by citing homology as evidence for common ancestry.

### 4. Haeckel’s Embryos

Darwin believed that all animals with backbones (including humans) evolved from fish-like ancestors, and he thought the best evidence for this was that the early embryos of amphibians, reptiles, birds and mammals are similar to fish embryos. Many biology textbooks carry drawings (originally by Ernst Haeckel) to illustrate this and claim that human embryos possess “gill slits.” But embryologists have known for over a century that such drawings are false and that early embryos of amphibians, reptiles, birds and mammals do NOT resemble fish. Human embryos pass through a stage when they have wrinkles in their necks, but they never have “gill slits.”<sup>v</sup>

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.”

## 5. *Archaeopteryx*

Darwin believed that modern species were linked in the past by innumerable transitional forms, but when he published his theory in 1859 those transitional links were missing. The discovery of *Archaeopteryx*, a bird fossil with reptile-like teeth, helped to persuade many people that Darwin’s theory was true, and many biology textbooks still feature *Archaeopteryx* as the “missing link” between reptiles and birds. Yet paleontologists no longer believe that *Archaeopteryx* was the ancestor of modern birds, and its own ancestors are the subject of heated controversy. The “missing link” between reptiles and birds, it seems, is still missing.<sup>vi</sup>

A = explains that the status of *Archaeopteryx* as a transitional link between reptiles and birds is controversial; points out that modern birds are probably not descended from it; mentions the controversy over whether birds evolved from dinosaurs or from a more primitive group; points out that the supposed dinosaur ancestors of *Archaeopteryx* do not appear in the fossil record until tens of millions of years after it.

B = explains that the status of *Archaeopteryx* as a transitional link between reptiles and birds is controversial; points out that modern birds are probably not descended from it; mentions the controversy over whether birds evolved from dinosaurs or from a more primitive group; but fails to point out that the supposed dinosaur ancestors of *Archaeopteryx* do not appear in the fossil record until tens of millions of years after it.

C = explains that the status of *Archaeopteryx* as a transitional link between reptiles and birds is controversial; points out that modern birds are probably not descended from it; but does not mention the controversy over whether birds evolved from dinosaurs or from a more primitive group.

D = presents *Archaeopteryx* as the transitional link between reptiles (or dinosaurs) and modern birds; does not point out that modern birds are probably not descended from it, but at least hints at the fact that there is a controversy over its ancestry or its transitional status.

F = presents *Archaeopteryx* as the transitional link between reptiles (or dinosaurs) and modern birds; does not point out that modern birds are probably not descended from it; and does not even hint at the fact that there is a controversy over its ancestry or its transitional status.

## 6. Peppered Moths

Darwin had no direct evidence for natural selection, the principal mechanism in his theory of evolution. Experiments in the 1950s seemed to provide the missing evidence by showing that light-colored peppered moths were more easily seen and eaten by predatory birds on pollution-darkened tree trunks, leaving mostly dark-colored moths to survive and reproduce. Many biology textbooks carry photographs of light and dark peppered moths on tree trunks to illustrate this famous story. Yet biologists have known for over a decade that the story has problems. Among other things, peppered moths don't normally rest on tree trunks, and the textbook photographs have been staged.<sup>vii</sup>

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.

## 7. Darwin's Finches

Many biology textbooks claim that finches on the Galápagos Islands, whose beak sizes are correlated with the foods they eat, helped to convince Darwin of evolution by natural selection in 1835. In reality, the legend of "Darwin's finches" was actually contrived a century later. Some textbooks also tell students that a slight increase in the average size of finch beaks, observed after a severe drought in the 1970s, shows how natural selection could produce a new species in only two hundred years. What these textbooks fail to mention is that the change was reversed when the rains returned, and no net evolution occurred.<sup>viii</sup>

A = explicitly points out that the Galápagos finches had little to do with the formulation of Darwin's theory; explains that selection on finch beaks oscillates between wet and dry years, producing no net evolutionary change; points out both that the genes affecting finch beaks are unknown and that hybrids between several species are now more fit than their parents, suggesting that those species may be merging.

B = explicitly points out that the Galápagos finches had little to do with the formulation of Darwin's theory; explains that selection on finch beaks oscillates between wet and dry years, producing no net evolutionary change; points out either that the genes affecting finch beaks are unknown or that hybrids between several species are now more fit than their parents, suggesting that those species may be merging.

C = describes the Galápagos finches as a good example of adaptive radiation (the origin of species by natural selection); but points out both that selection on finch beaks oscillates between wet and dry years and that the finches did not play an important role in the formulation of Darwin's theory.

D = describes the Galápagos finches as a good example of adaptive radiation (the origin of species by natural selection); but points out either that selection on finch beaks oscillates between wet and dry years or that the finches did not play an important role in the formulation of Darwin's theory.

F = describes the Galápagos finches as a good example of adaptive radiation (the origin of species by natural selection); but fails to mention

that selection on finch beaks oscillates between wet and dry years, and implies that the finches played an important role in the formulation of Darwin's theory.

## 8. Whales

Darwin advocates have described whale evolution as the “poster child”<sup>jix</sup> of macroevolution, and biology textbooks have followed suit. In the past 10 years textbooks have increasingly included whale evolution from land mammals as a supposed example of fossils demonstrating “macroevolution.” Textbooks typically portray reconstructed drawings of ancient fossils, claiming they are “intermediate” forms. These fossil reconstructions and claims about the lifestyles and behaviors of these fossils are heavily based upon evolutionary interpretation and are not raw deductions from the hard data. Textbooks rarely reveal this. Moreover, textbooks also rarely mention the short amount of geological time (< 10 my) available for this evolutionary transition under the fossil record. The numerous complex molecular, anatomical, and behavioral modifications necessary to convert a small land mammal into a fully aquatic whale could not be achieved by unguided neo-Darwinian processes in such a short period of time. Textbooks fail to mention such problems with this evolutionary story.<sup>x</sup>

A = mentions the whale sequence and acknowledges the limited amount of time in the fossil record (<10 million years) available for this evolutionary sequence; lists various anatomical changes necessary to convert a land mammal to a fully-aquatic whale and observes that population genetics (perhaps mentioning Haldane’s dilemma) would make such a transition very unlikely to occur via unguided neo-Darwinian processes under the available timescale; shows pictures illustrating purported reconstructions of protowhale species and notes that the specific lifestyle and form of these species may be the result of interpretation, not hard data.

B = mentions the whale sequence and acknowledges the limited amount of time in the fossil record (<10 million years) available for this evolutionary sequence; observes that population genetics (perhaps mentioning Haldane’s dilemma) would make such a transition very unlikely to occur via unguided neo-Darwinian processes under the available timescale; shows pictures illustrating purported reconstructions of protowhale species and notes that the specific lifestyle and form of these species may be the result of interpretation, not hard data.

C = mentions the whale sequence and acknowledges the limited amount of time in the fossil record (<10 million years) available for this evolutionary sequence; shows pictures illustrating purported reconstructions of protowhale species and notes that the specific lifestyle and form of these species may be the result of interpretation, not hard data.

D = mentions the whale sequence and acknowledges the limited amount of time in the fossil record (<10 million years) available for this evolutionary sequence; shows pictures illustrating purported reconstructions of protowhale species but does not note that the specific lifestyle and form of these species may be the result of interpretation, not hard data.; may use a polemical style that claims these fossils are “missing links.”

F = mentions the whale sequence but says nothing about the limited amount of time in the fossil record (<10 million years) available for this evolutionary sequence;

shows pictures illustrating purported reconstructions of protowhale species but does not note that the specific lifestyle and form of these species may be the result of interpretation, not hard data; may use a polemical style that claims these fossils are “missing links.”

## 9. Junk-DNA

Textbooks often claim that our cells are full of noncoding junk DNA. They may suggest that specific DNA elements—such as pseudogenes, introns, and other forms of “selfish DNA”—demonstrate our evolutionary history. However, these textbooks rarely discuss the extensive evidence of biological function that has been discovered for noncoding DNA in recent years. Even pseudogenes are increasingly expected to have function. While some textbooks may hint that function is suspected, there are rarely outright statements that the “junk” DNA paradigm has now been overturned by over a quarter of a century of genetics and molecular biology research.<sup>xi</sup>

A = clearly states that recent discoveries have led many scientists to suspect that most noncoding DNA has function and is not junk; notes that the junk DNA paradigm was the result of the neo-Darwinian thinking, and notes that such thinking hindered scientific progress by repelling researchers from seeking to understand the function of non-coding DNA. Also, does not claim that “junk” DNA provides evidence for neo-Darwinian evolution.

B= clearly states that recent discoveries have led many scientists to suspect that most noncoding DNA has function and is not junk; notes that the junk DNA paradigm was the result of the neo-Darwinian thinking, but does not note that such thinking hindered scientific progress. Also, does not claim that “junk” DNA provides evidence for neo-Darwinian evolution.

C = clearly states that recent discoveries have led many scientists to suspect that much noncoding DNA is not junk; but does not note that the junk DNA paradigm was the result of the neo-Darwinian thinking, and does not note that such thinking hindered scientific progress. Also, does not claim that “junk” DNA provides evidence for neo-Darwinian evolution.

D = does not clearly state that recent discoveries have led many scientists to suspect that much noncoding DNA is not junk, although it may weakly suggest that some noncoding DNA might possibly have function. May claim this provides evidence for a neo-Darwinian evolutionary history.

F = expressly states or implies that much or most noncoding DNA is junk; may claim that this provides evidence for a neo-Darwinian evolutionary history; states that specific types of non-coding DNA elements, such as pseudogenes or introns are likely useless genetic junk.

## **VI. Grading Notes and Comments About Specific Textbooks**

### **1. Colleen Belk and Virginia Borden Maier, *Biology: Science for Life* (Benjamin Cummings, 3<sup>rd</sup> ed., 2010).**

#### Icons Grading Notes:

*The Miller-Urey Experiment:* Contains Miller-Urey apparatus picture. Both text and caption mislead students to think the experiments accurately modeled the Earth's early atmosphere and contained methane and ammonia. The text states that Miller "attempted to re-create conditions on early Earth within a laboratory apparatus" (p. 248), and the caption states, "This apparatus simulated conditions on early Earth." (p. 249) There are no qualifications of these statements in the text. **Grade: F.**

*Darwin's Tree of Life:* The textbook treats common descent as an uncritical fact, stating, "All species present on Earth today are descendants of a single common ancestor." (p. 228) It treats this concept as an establish fact: "The evidence put forth in *The Origin of Species* was so complete, and from so many different areas of biology, that the hypothesis of common descent no longer appeared to be a tentative explanation." (p. 230) The book treats this topic like an argument which must be won with rhetoric. It sides with "all those scientists who insist that the theory of common descent is fact." (p. 231) It concludes, "Scientists favor the theory of common descent because it is the best explanation or how modern organisms came about. The theory of evolution—including the theory of common descent—is robust, meaning that it is a good explanation for a variety of observations and is well supported by a wide variety of evidence from anatomy, geology, molecular biology, and genetics." (p. 249) It mentions the Cambrian explosion in the body of the text (p. 325), but it does not mention how it challenges neo-Darwinism. **Grade: D.**

*Homology in Vertebrate Limbs:* The textbook defines homology as "[s]imilarity in characteristics as a result of common ancestry" (p. G-10) and "[i]f modern species represent the descendants of ancestors that also gave rise to other species, we should be able to observe other, less-obvious similarities between humans and apes in anatomy, behavior, and genes. These similarities are referred to as homology." (p. 237) The textbook then, however, claims that these homologous similarities are evidence for common ancestry: "Shared characteristics among humans and apes imply shared ancestry." (p. 238) It further states: "Homology of mammal forelimbs. ... The similarity is underlying structure despite great differences in function is evidence of shared ancestry." (p. 233) There is no mention of evidence that does not fit the claims of homology. **Grade: F.**

*Haeckel's Embryos:* The textbook uses photos of embryos, but they are selectively chosen to show the pharyngular stage. The caption states: "These diverse organisms appear very similar in the first stages of development ... evidence that they share a common ancestor that developed along the same pathway." (p. 234) There is no mention of dissimilarity in earlier stages of development. **Grade: D.**

*Archaeopteryx:* N/A.

*Peppered Moths:* N/A.

*Darwin's Finches:* The textbook mentions the Galápagos finches as an example of evolution by natural selection (pp. 260-261). It does not imply that the finches played a role in the formulation of Darwin's theory, but it also does not directly state that they did *not* play a major role in Darwin's thinking. It states that "scientists have observed that when rainfall is scarce, a large bill is an adaptation" (p. 261), but never notes that after a drought beak sizes returned to normal. Because it does not imply that finches were important to Darwin, it gets a D- instead of an F. **Grade: D-.**

*Whales:* N/A.

*Junk-DNA:* N/A.

*Other Notes:*

The textbook authors must feel threatened by Darwin-skepticism, as they devote half a page to attacking Discovery Institute's "Dissent from Darwin" list. The critique attempts to flatter the student as a "Savvy Reader," but only asks students to "critique the argument," seeking to direct the student to dismiss the existence of scientific dissent from Darwinism. (p. 251) Perhaps the "Savvy Reader" section wants students to accept arguments from authority rather than form their own opinions after examining the evidence. At least students will feel good, thinking that by simply agreeing with the consensus, they're being "savvy." **Overall Grade: F.**

**2. Alton Biggs, Whitney Crispen Hagins, Chris Kapicka, Linda Lundgren, Peter Rillero, Kathleen G. Tallman, Dinah Zike, *Biology: The Dynamics of Life* (Glencoe, 2006) (Florida Edition).**

*Icons Grading Notes:*

*The Miller-Urey Experiment:* Contains Miller-Urey apparatus picture. Misleading captions states, "Miller and Urey's experiments showed that under the proposed conditions on early Earth, small organic molecules, such as amino acids, could form." No qualification is in the text. In fact, the text contains a highly dubious statement: "In the 1950s, various experiments were performed and showed that if the amino acids are heated without oxygen, they link and form complex molecules called proteins" (p. 383). **Grade: F.**

*Darwin's Tree of Life:* On pages 454-455 of this textbook there is a "phylogenetic diagram" of all the kingdoms of life, portraying all living groups as being related. It states, "The fan's rays represent the probable evolution of species from the common origin." (p. 455) This view is portrayed as fact without any question. The "Cambrian explosion" is mentioned, as it states that "the fossil record shows an enormous increase in the diversity of life forms during this time" (p. 377); however, there is no mention of how it is a challenge to neo-Darwinian evolution. **Grade: D.**

*Homology in Vertebrate Limbs:* The textbook defines homology as resulting from common ancestry, stating: "Structural features with a common evolutionary origin are called homologous structures." (p. 400) Then it uses homology as evidence for common ancestry, stating: "Evolutionary biologists view such structural similarities as evidence that organism evolved

from a common ancestor.” (p. 400) There is no mention of data that does not fit with the claims of homology. **Grade: F.**

*Haeckel's Embryos:* The textbook uses photos of embryos which are selectively chosen to fit with neo-Darwinian theory, although they could be worse. It tries to emphasize their similarities stating: “At this stage of development, all the embryos have a tail and pharyngeal pouches. . . . It is the shared features in the young embryos that suggest evolution from a distant, common ancestor.” It does note that “[i]n other stages of embryonic development, these organisms look different. However, at some point they look similar.” (p. 402), It doesn’t note that their earlier stages show more differences. Finally, it asks students to “[h]ypothesize the strengths and weaknesses of embryology as evidence for evolution.” Since students are only given information in the text about evidence that supports common ancestry, they have few tools to effectively hypothesize these strengths and weaknesses. Despite the inaccurate text and bias, since the text notes that the embryos can be different and also asks students to critically analyze the data, it will receive a D+ rather than a D. **Grade: D+.**

*Archaeopteryx:* The text states that *Archaeopteryx* “supports the idea that modern birds evolved from dinosaurs.” (p. 378) A diagram on page 832 shows that *Archaeopteryx* may not be ancestral to modern birds and the text states, “At first, scientists thought that *Archaeopteryx* was a direct ancestor of modern birds, however, some paleontologists now think it most likely did not give rise to any other bird groups.” (p. 832-833) No hint is made of controversy over the general hypothesis that birds evolved from dinosaurs. **Grade: C.**

*Peppered Moths:* The textbook uses a staged drawing of the moths and claims that “[t]he moths sometimes rested on trees,” and “[s]ome birds eat peppered moths.” (p. 397) No mention is made of problems with the original experiments. **Grade: F.**

*Darwin's Finches:* The textbook calls the Galápagos finches an example of “adaptive radiation” and claims that feeding adaptations evolved on the islands (p. 469), No mention is made that the finches can interbreed. The textbook also states, “The observations that Darwin made and the specimens that he collected there were especially important to him. On the Galápagos Islands, Darwin studied many species of animals and plants . . . These observations led Darwin to consider the possibility that species can change over time.” (p. 394) The finches are mentioned on this page, and the reader is left with the impression that studies of Galápagos finches were important to the development of Darwin’s theory. However, the textbook doesn’t really discuss the experiment that claims finches evolved in response to a drought. As a result, the highest grade it can receive is a D. **Grade: D.**

*Whales:* N/A.

*Junk-DNA:* N/A.

*Other Notes:*

This textbook is rare in that it asks students to look at the “strengths and weaknesses” (p. 402) of the evidence regarding evolution. However, the textbook only presents a pro-Darwin viewpoint, meaning this is once again faux-inquiry. How can students evaluate the “weaknesses” when none are presented? In fact, this textbook pushes evolution ardently, stating: “The modern theory of evolution is the fundamental concept in biology.” (p. 393) **Overall Grade: D-.**

### **3. BSCS Biology: A Human Approach (Kendall Hunt Publishing Company, 2006).**

#### Icons Grading Notes:

*The Miller-Urey Experiment:* N/A.

*Darwin's Tree of Life:* The textbook's chapter 3, "Products of Evolution: Unity and Diversity," promotes the tree of life as fact. It opens with a quote from E.O. Wilson: "Great biological diversity takes long stretches of geological time and the accumulation of large reservoirs of unique genes." (p. 62) The textbook then says: "the diversity resulted from evolution," (p. 64) and "[l]iving systems share different characteristics as a result of their common ancestry." (p. 73) Regarding classification, it attributes it to common ancestry: "the act of creating classification categories helps them think about the evolutionary relationships that exist among different types of organisms. In fact, we might say that classification categories represent hypotheses that biologists develop about how different forms of life are related ... A classification scheme in which objects are first sorted into large categories and then into smaller groups within the larger categories is said to be **hierarchical**." (p. 74) Pages 76-77 feature a tree diagram showing the relatedness of all living animals. While it admits that "controversies" arise when classifying organisms (p. 78), there is no question about the overall fact of common ancestry. For example, it states: "The similarity in genetic code across living organisms strongly suggests a common origin for all modern life" (p. 109) and "classification criteria, which reflect the pattern of evolutionary change, often are characteristics that are, or once were, adaptations." (p. 141) It also states, without qualification, that "[e]volution from a common ancestor, however, also has resulted in organisms that show important similarities to each other." (p. 81, emphasis in original) There is no mention of the Cambrian Explosion. **Grade: F.**

*Homology in Vertebrate Limbs:* The textbook defines homology as similarity of structure and position, as well as due to common ancestry, stating, "Because of these consistent similarities, biologists infer that the forelimb structure is a homology. A homology is a characteristic that is similar among different organisms because they evolved from a common ancestor." (p. 107) It then, however, claims that homology is evidence for common ancestry, stating: "Homologies are characteristics that suggest common ancestry." (p. 108) Since part of its definition of homology is "because they evolved from a common ancestor," and it then states that homologies "suggest common ancestry," it uses circular reasoning to define the topic. No mention is made of genetic or developmental evidence that does not fit with evolutionary claims regarding homology.

**Grade: F.**

*Haeckel's Embryos:* On page 46, the textbook recommends that teachers use an "embryo puzzle" handed out by the teacher. I have obtained a copy of this puzzle from an anonymous biology teacher who used this textbook in the public school setting. The puzzle uses Haeckel's original drawings, which students are asked to cut up and then arrange in the proper order. The textbook states: "Scientists can compare the developing embryos of organisms as diverse as fish, amphibians, reptiles, birds, and mammals. They find that the embryos of these vertebrate animals (animals that have backbones) resemble each other." (p. 46) The textbook then instruct students to do the following with the embryo puzzle: "Study the individual drawings of embryos that your teacher provides. Try to arrange all of the embryonic stages in a developmental order for each animal. When you have finished, your arrangement should show 3 stages of embryonic development for a fish, a frog, a chicken, a calf, and a human." (p. 46) As an ineffective attempt

at qualification, it states: “These stages are relative. They do not represent the same point in time, but rather the same amount of development.” (p. 46) The exercise then asks, “What do you think these similarities and differences tell scientists about how these organisms have changed across time and how they are related?” (p. 46) In a passage that hints of the concept that ontogeny recapitulates phylogeny, it states: “Consider whether you expect related organisms to look similar or not. Would you also expect related organisms to go through similar stages of development? Consider the later stages of development. Do the more closely related organisms look more or less similar?” (p. 46) **Grade: F.**

*Archaeopteryx*: N/A.

*Peppered Moths*: N/A.

*Darwin’s Finches*: The textbook describes the Galápagos finches as a good example of adaptive radiation, stating: “As natural selection began adapting these populations to their new island environments, they diversified into the different finch species we see today. This process of diversification from a single ancestor into several related species through natural selection is called *adaptive radiation*.” (p. 748) Although not as bad as some textbooks, this textbook also implies that the Galápagos finches played an important role in the formulation of Darwin’s theory. Calling them “Darwin’s finches” (p. 748), the textbook states that Darwin’s voyage on the Beagle “included stops in South America and a stay in the Galápagos islands. During the trip, Darwin collected evidence that he later used to support the theory of evolution.” (p. 112) The textbook never explains that the finches did not play an important role in the formulation of Darwin’s theory. The textbook claims that finch beaks change in response to weather patterns, stating: “During a 12-year period, the scientists recorded measurements of the size of the birds’ bodies and the thickness of their beaks. During this time, there were two extreme dry spells, and many birds of each species died. At the end of the observation period, the scientists noticed that the average characteristics in the surviving populations of both species had changed slightly. The birds that survived, and their offspring, were a little larger and had beaks that were a little thicker than before. The scientists had witnessed a small but ongoing biological change that was influenced by natural circumstances and could be inherited. These support the conclusion that species change gradually. They also suggest that across very long periods of time, small change might add up to significant differences.” (p. 107) There is no mention that during wet periods, the birds oscillated back to the state they held before the drought. **Grade: F.**

*Whales*: The textbook mentions the whale sequence but also mentions the timeline. It states: “Scientists have hypothesized that modern whales are descended from land mammals that moved into the water environment between 50 to 60 million years ago.” (p. 671) In the diagram on page 672, the fossils in the whale sequence are presented from 40 to 55 mya. This is not a clear mention of the timescale, but since dates are mentioned, it will be given a D-. It contains drawings and reconstructions of alleged whale ancestors but never suggests that these are merely reconstructions. It does not note that fossil reconstructions may be based upon evolutionary interpretation, and not hard data. **Grade: D-**.

*Junk-DNA*: N/A.

Other Notes:

This textbook has an unusual structure in that the first lecture of the first chapter of the first section of the book promotes human evolution and encourages student to read about Jane Goodall, emphasizing the similarities between humans and apes. In essence, students are expected to learn and accept that humans evolved from other primates in the very first lecture of the book—*when they have not yet even learned what a cell is*. This book seems to have a strong agenda to indoctrinate in evolutionary ideas, not to teach biology in a logical fashion. An anonymous public school biology instructor who has been forced to teach from this textbook told me the following about it:

While I would recommend other BSCS textbooks I've used, this one raised pedagogical and academic concerns. In particular, both my colleagues (who support evolution) and I thought it was inappropriate that the textbook started, from the get-go, by promoting human evolution from primates. This is unusual for two reasons.

It's an unusual starting point in that it seems premature to introduce evolutionary biology when students had not yet encountered the underlying basic biological topics like the cell or DNA. If the vehicle for evolution is DNA mutations, then students must at the very least encounter that concept before studying evolution.

Additionally, starting the year with the most controversial topic in the entire course generated controversy and division among my students at a critical time when I needed to have them on board for the remainder of the year. Whether or not one agrees with evolution, it seems like an unnecessary and unwise decision to start the book with the most controversial chapter and topic -- the idea that humans descended from primates. Again, this concern was shared not just by me but also my colleagues who are evolutionists. Any good teacher would know that you don't start with the most controversial topic at hand when the beginning of the year should be used to build bridges, excitement, and enthusiasm.

The textbook did not use good teaching practice. The authors seemed to have an evolutionary agenda that overrode not just logical pedagogy but any sensitivity towards the multiple viewpoints that students walk in with at the start of the school year.

In other words, this textbook put a pro-evolution agenda before principles of good education—so much so that even evolution-friendly teachers felt its structure was illogical. **Overall Grade: F.**

#### **4. BSCS Biology: A Molecular Approach (Glencoe/McGraw Hill, 2006).**

##### Icons Grading Notes:

*The Miller-Urey Experiment:* Contains Miller-Urey apparatus picture. Both text and caption misleads students to think the atmosphere contained methane and ammonia. The text states that Miller “recreated conditions that might have existed on Earth 4.6 billion years ago” (p. 447) without any qualification. Likewise, the caption states, “Miller used this equipment to recreate conditions thought to exist in the Earth’s primitive atmosphere.” (p. 447) No qualifications are given about problems with these statements. **Grade: F.**

*Darwin’s Tree of Life:* The textbook treats common descent as an uncritical fact, stating that various vertebrate groups “share an ancestor.” (p. 467) “Scientists use molecular data together

with other lines of evidence to explain evolutionary relationships,” featuring trees purporting to show the evolutionary relationships of major mammal groups (p. 530) and a diagram claiming that mammals, birds, and fish are related (p. 472). It makes no mention of the Cambrian explosion. **Grade: F.**

*Homology in Vertebrate Limbs:* The textbook defines homology as similarity of structure and position, stating that “structural resemblances are called homologies.” (p. 466) It also cites homology as evidence for common ancestry, saying that “homologies … provide evidence that these animals share an ancestor.” (p. 467) It fails to discuss data that does not fit with claims of homology. **Grade: D.**

*Haeckel’s Embryos:* The textbook uses drawings which show the differences between the early stages of vertebrate embryos and are not misleading (p. 270). It also notes that the earliest stages, such as cleavage, are “very different in birds and mammals.” (p. 270) However, it attempts to explain all of this in terms of Darwinian evolution, stating, “Even though birds and mammals start development quite differently, morphogenesis in both follows a similar genetic program inherited from a common ancestor.” (p. 270). There is no mention of unresolved problems for Darwinian evolution. **Grade: C.**

*Archaeopteryx:* The textbook presents *Archaeopteryx* as the transitional link between dinosaurs and modern birds, stating: “In recent years, great excitement has been raised over fossils that seem to bridge the morphological gap between carnivorous dinosaurs, the theropods *Tyrannosaurus rex* and *Velociraptor*, and birds, an early example of which is *Archaeopteryx*.” It further states, “Despite the dinosaurlike claws, teeth, and tail, this fossil shows the highly advanced shoulder girdle that allowed for flapping arms, a feature almost identical to that of *Archaeopteryx*, the earliest known bird.” (p. 503) It does not point out that modern birds are probably not descended from it, and it does not hint that there is controversy over its ancestry or transitional status. **Grade: F.**

*Peppered Moths:* The textbook uses drawings which appear to contain photos that are staged (p. 424). In any case, they are a completely artificial representation and they misrepresent the natural resting place of moths, as they explicitly show moths on tree trunks and state, “The moth flies at night and rests on tree trunks during the day.” (p. 423) It attributes the changes to natural selection: “One of the best-known examples of natural selection involves the English peppered moth (*Biston betularia*).” (p. 423) There is no hint that there are problems with the classical story. **Grade: F.**

*Darwin’s Finches:* The textbook describes the Galápagos finches as a good example of adaptive radiation, stating, “The adaptations of Darwin’s finches to different food sources and nesting sites on the Galápagos Islands provides an example of adaptive radiation.” (p. 511) The textbook also implies that the finches played an important role in the formulation of Darwin’s theory, stating: “On the Galápagos Islands, which Darwin visited during his travels, some members of the same finch species have short, thick beaks while others have longer, thinner beaks. On the basis of these observations, Darwin concluded that some variations would help members of a species survive in a particular environment, whereas other variations would not be helpful.” (pp. 10-11) It also makes no mention that the selection on the finches oscillates between dry and wet seasons, simply stating: “scientists have observed that during drought Galápagos finches with long, thin beaks tend to be at a disadvantage because they cannot crack the tough seeds that are plentiful under those conditions.” (p. 11) **Grade: F.**

*Whales:* N/A.

*Junk-DNA:* The textbook implies that most DNA does not have function, stating: “Only part of this DNA codes for proteins. Noncoding DNA is not translated. Some noncoding DNA consists of short sequences of bases repeated thousands of times. About 1.5% of DNA is expressed as protein. The importance of most of the rest is unclear.” (pp. 347-348) However, the teacher’s notes do say, “Encourage students to research the significance of noncoding DNA. The function of most of these sequences I unknown, although some are involved with regulating gene expression. Repetitive sequences may contribute to chromosome stability by binding to chromosomal proteins.” (p. 348) It also states that nonfunctional pseudogenes are common and claims that they provide evidence for evolution, without making any mention of discovery of function for them. It states: “One kind of mutation that provides evidence of the history of evolution is gene duplication. Duplication of a gene produces gene families—multiple copies of nearly identical DNA sequences. Some of the copies, called pseudogenes, no longer function. They are neither transcribed nor translated. Because pseudogenes are not expressed, they are not subjected to natural selection. Therefore, evolutionary theory predicts pseudogenes accumulate mutations faster than functional genes in the same family. Genetic studies have confirmed this prediction.” (p. 506) It further states that “comparisons of nonfunctioning pseudogenes … also provide important clue as to how closely related two species may be.” (p. 531) **Grade: F.**

*Other Notes:*

This “molecular”-focused textbook cherry-picks molecular data in favor of neo-Darwinian evolution. For example, it cites “non-functioning pseudogenes” as evidence of evolution (p. 531) and earned an F for the icon of junk-DNA. It also fails to mention evidence of potential functions for pseudogenes. Similarly, on page 227 it portrays the cytochrome C tree and the anatomy-based tree and states, “These two methods generally agree.” (p. 530) However, it cherry picks data from the cytochrome c tree and fails to mention that the cytochrome b tree has significant differences from the standard phylogeny based upon the fossil record or comparative anatomy. As one article in *Trends in Ecology and Evolution* stated: “[T]he mitochondrial cytochrome b gene implied . . . an absurd phylogeny of mammals, regardless of the method of tree construction. Cats and whales fell within primates, grouping with simians (monkeys and apes) and strepsirrhines (lemurs, bush-babies and lorises) to the exclusion of tarsiers. Cytochrome b is probably the most commonly sequenced gene in vertebrates, making this surprising result even more disconcerting.”<sup>xii</sup> It is typically dogmatic about evolution, stating: “Evolution—like the scientific theories of gravity, plate tectonics, atomic structure, and cell structure—is indeed a theory. It is one of the most important ideas in biology,” and “To a scientist, calling evolution a theory is a statement of confidence if the theory has been well-tested scientifically and is supported by a large body of evidence.” (pp. 500-501) It even says, “Theories such as evolution theory . . . have been supported repeatedly by data resulting from hypotheses. In addition, virtually no opposing data have yet been found.” (p. 13) It also discusses the controversial “Gaia Hypothesis,” which claims “our planet is a single complex living organism.” (p. 676) **Overall Grade: F.**

**5. BSCS Biology: An Ecological Approach (10<sup>th</sup> ed., Kendall Hunt Publishing Company, 2006).**

*Icons Grading Notes:*

*The Miller-Urey Experiment:* Contains Miller-Urey apparatus picture; both text and caption mislead students to think the atmosphere contained methane and ammonia; contains one minor qualification, which starts with a gross overstatement: “Although these experiments suggest a way in which life might have originated, it is still a long way from complex molecules to even the simplest of known organisms.” (p. 282) **Grade: D-.**

*Darwin’s Tree of Life:* The textbook treats common descent as an uncritical fact, stating: “Each species alive today is the tip of a branching tree that extends far back in time to an ancient earth inhabited by gradually changing populations of organisms. How did today’s species come to be? Evolution, change through time (genetic change through time), is the biological process that links all species, no matter how they differ.” (p. 233) On page 276 is a single tree of life which shows all five kingdoms of organisms, with a caption that states: “Currently all organisms can be classified in the five-kingdoms shown in this diagram.” (p. 276) The textbook does describe many of the fauna which lived in the Cambrian period (see, for example, p. 603), but it never describes their explosive appearance or uses the term “Cambrian Explosion.” **Grade: D-.**

*Homology in Vertebrate Limbs:* The textbook defines homology in terms of similarity of structure: “For example, fish, amphibians, reptiles, birds, and mammals all share the same limb patter … The limbs have the same relationship to the body, and they develop in the same way as the young. These types of relationships are called structural homologies.” (p. 266-267). It also defines homology in terms of common ancestry: “likeness in form, as a result of evolution from the same ancestors.” (p. 796) It also uses homology to argue for common ancestry, calling homologies “[s]imilarities of structure that indicate *related ancestry*.” (p. 267) It never mentions any evidence that challenges claims of homology. Since it initially defines homology in terms of structure and only later defines it in terms of ancestry, it will receive a D- instead of an F.

**Grade: D-.**

*Haeckel’s Embryos:* This textbook uses drawings of early vertebrate embryo stages. The drawings reflect many differences between embryos in the early stages. It states “the intermediate stages of embryologic development are remarkably alike” (p. 235), thus implying that stages before the intermediate stage are more dissimilar. It also disclaims ontogeny recapitulates phylogeny, stating: “These similarities do not mean that a human passes through fish, amphibian, or reptile stages during development.” (p. 235) However, it implies these similarities are explained by common ancestry, which had already been stated as fact a couple pages prior: “the similarities show that the same fundamental processes occur in the development of many different structures found in vertebrates.” (p. 235) Because this is only implied and not stated outright, it will receive a B; it does not consider the possibility that Darwin’s theory was wrong. **Grade: B.**

*Archaeopteryx:* N/A. The textbook does mention *Archaeopteryx* but only briefly, and it gives very little description (p. 233). There is insufficient information given to grade the textbook on this icon.

*Peppered Moths:* This textbook uses staged photos but notes that they were “pinned on a tree.” Still, it suggests that the moths rest on tree trunks: “The prevailing hypothesis describing the basis for selection in the peppered moth (*Biston betularia*) is that birds will eat the insect that is most obvious on a tree trunk.” (p. 242) It also states, “Darker moths were rare, and they were usually eaten by birds because they were so visible against the light-colored trees. … As soot

darkened the tree bark and covered the lichens, the light-colored moths became easier to see and darker moths became less visible. Birds began to eat the conspicuous light-colored moths..." (p. 241) While it mentions no problems with the experiments, it notes that they were "pinned on at tree" and that the pictures are artificial. **Grade: D-**.

*Darwin's Finches:* The textbook implies that the Galápagos finches were important to the development of Darwin's theory: "The Galápagos Islands, off the coast of Ecuador, particularly interested Darwin. As he explored these islands, Darwin encountered a fascinating assortment of plants and animals. He collected many biological specimens, including marine and land iguanas and various types of birds. ... When Darwin finally returned to England, he continued studying the specimens he had collected during the long voyage. His collection of Galápagos finches was examined by specialists who determined that the specimens represented 13 species, differing primarily in the size and shape of their beaks. Darwin surmised that these finches must originally have come from the South American mainland, but why, he wondered, were these island birds so different from finches found on the mainland? Also, why did the assortment of finches differ so much from one island to the next?" (p. 238) A diagram states, "The variations in the sizes of finch beaks has adapted to gathering that species' primary food source." (p. 239) There is no mention that the finches can interbreed, nor was there mention of the study where beak sizes increased during a drought. The highest grade it can receive is a D. **Grade: D.**

*Whales:* N/A.

*Junk-DNA:* N/A.

*Other Notes:*

This textbook received one of the highest grades for an individual icon, as it received a B for Haeckel's embryos because it acknowledges the differences between the earliest stages of embryos. But on the whole, it is adamantly pro-evolution-only, as it states at the beginning of its Evolution chapter, "The process of evolution explains both biological diversity and the unity of life." (p. 233) **Overall Grade: D+.**

**6. Neil A. Campbell, Jane B. Reece, Martha R. Taylor, Eric J. Simon, Jean L. Dickey, *Biology: Concepts and Connections* (6<sup>th</sup> Ed., Pearson, 2009).**

*Icons Grading Notes:*

*The Miller-Urey Experiment:* Contains Miller-Urey apparatus picture. With only a minor qualification, the text misleads students to think the experiments accurately modeled the Earth's early atmosphere and contained methane and ammonia. Text states: "The first atmosphere was probably thick with water vapor, along with various compounds released by volcanic eruptions, including nitrogen and its oxides, carbon dioxide, methane, ammonia, hydrogen, and hydrogen sulfide." (p. 294) The text further states: "Miller was the first to show that amino acids and other organic molecules could be formed under conditions believed to simulate those of the early Earth" (p. 295) and quotes Stanley Miller saying, "Oparin proposed that the primitive atmosphere contained the gases methane, ammonia, hydrogen and water, and that the chemical reactions in that primitive atmosphere produced the first organic molecules." (p. 295) The minor qualification says: "Scientists now think that the composition of the atmosphere of the early Earth was somewhat different from what Miller assumed in his historic first experiment," but it

goes on to wrongly claim that, in the right atmosphere, “some recent Miller-Urey-type experiments using such atmospheres have produced organic molecules,” and “it is possible that small ‘pockets’ of the early atmosphere—perhaps near volcanic openings—were similar to those used by Miller.” (p. 295) **Grade: D.**

*Darwin’s Tree of Life:* The textbook treats common descent as an uncritical fact, stating that “[a] mass of other evidence reinforces the evolutionary view of life,” (p. 262) and “[h]omologies indicate patterns of descent that can be shown on an evolutionary tree” (p. 263). It mentions the Cambrian explosion in the body of the text (p. 367), but it does not mention how it challenges neo-Darwinism. It treats the tree of life as a fact, but it does mention that some trees are hypotheses: “Evolutionary trees are hypotheses reflecting our current understanding of patterns of evolutionary descent. Some trees are more speculative because less data may be available. Others, are based on strong combinations of fossil, anatomical, and DNA sequence data.” (p. 263) As a result, this will be graded slightly better than D, as D+. **Grade: D+.**

*Homology in Vertebrate Limbs:* The textbook defines homology as similarity due to inheritance from a common ancestor, then in a circular fashion uses homology as evidence for common ancestry. The textbook thus defines homology as follows: “Similarities in characteristics that results from common ancestry is known as homology,” (p. 262) further stating that “[b]iologists call such anatomical similarities in different organisms homologous structures—features that often have different functions but are structurally similar because of common ancestry.” (p. 262) The circularity is seen when these homologous similarities are given as evidence for common ancestry: “Anatomical similarities between many species give signs of common descent.” (p. 262) There is no mention of evidence that does not fit with claims regarding homology. **Grade: F.**

*Haeckel’s Embryos:* The textbook uses photos rather than pictures, but the photos are selectively taken from the so-called pharyngular stage (p. 263). It gives no hint that embryos are dissimilar in earlier stages. **Grade: D.**

*Archaeopteryx:* The textbook presents *Archaeopteryx* as the transitional link between dinosaurs and modern birds, stating, “Like living birds, it had feathered wings, but otherwise it was more like a small bipedal dinosaur of its era, without its teeth, wing claws, and tail with many vertebrae.” (p. 328) It does not point out that modern birds are probably not descended from it, and it does not hint that there is controversy over its ancestry or transitional status. **Grade: F.**

*Peppered Moths:* N/A.

*Darwin’s Finches:* The textbook describes the Galápagos finches as a good example of evolution by natural selection, stating, “But do we have examples of natural selection in action? Indeed, biologists have documented evolutionary change in thousands of scientific studies. A classic example involves Peter and Rosemary Grant’s work with finches in the Galápagos islands...” (p. 259) The textbook does acknowledge that selection on the finch beaks oscillates between wet and dry years. “In dry years, when all seeds are in short supply, birds must eat more large seeds,” but “[d]uring wet years, smaller beaks are more efficient for eating the now abundant small seeds, and the average beak size decreases.” (p. 259) However, it implies that the finches played an important role in the development of Darwin’s ideas, stating that Darwin’s “observations in the Galápagos contributed greatly to his theory of evolution,” (p. 255) and “[i]f you visit the Galápagos Islands today, you will see many of the same sights that fascinated

Darwin over a century ago... You may observe some of the finches Darwin collected... One of Darwin's lasting contributions is the scientific explanation for the striking ways in which organisms, such as these diverse inhabitants of the Galápagos islands, are suited for life in their environment. “ (p. 256) It later states that Peter and Rosemary Grant confirmed Darwin's purported hypothesis about the finches, stating: “Some hypotheses wait a long time to be tested. Such was the case with Darwin's 150-year-old hypothesis that the beaks of the diverse Galápagos finch species had adapted to different food sources through natural selection.” (p. 287) **Grade: D.**

*Whales:* The textbook mentions the whale sequence but says nothing about the limited amount of time available for this transition. It also does not note that fossil reconstructions may be based upon evolutionary interpretation, and not hard data. (p. 261) **Grade: F.**

*Junk-DNA:* The textbook acknowledges that recent discoveries have led many scientists to suspect that much noncoding DNA is not junk, stating, “Until recently, most of the remaining DNA was considered to be ‘noncoding,’ meaning that it neither coded for proteins nor was transcribed into functional RNA of the few known types. In other words, it was thought not to contain meaningful genetic information. However, a flood of recent data has contradicted this view. Biologists currently think that a significant amount of the genome may be transcribed into non-protein-coding RNAs, including a variety of small RNAs. While many questions about the functions of these RNAs remain unanswered, researchers are uncovering more evidence of their biological roles every day.” (p. 215) However, it does not note that junk-DNA paradigm was the result of evolutionary thinking, but it also does not imply that junk DNA provides evidence for evolution. **Grade: C.**

Other Notes:

This textbook contains a good example of a faux-critical thinking exercise, as it asks students: “Write a paragraph briefly describing the kinds of evidence for evolution.” (p. 275) No questions ask students to identify evidence that counters evolutionary biology, because no such evidence is presented in the text. **Overall Grade: D.**

**7. Scott Freeman, *Biological Science* (4<sup>th</sup> ed., Benjamin Cummings / Pearson, 2011).**

Icons Grading Notes:

*The Miller-Urey Experiment:* The textbook contains a drawing of the Miller-Urey apparatus and the caption asks, “Which parts of the apparatus mimic the ocean, atmosphere, rain, and lightning?” (p. 39) The implication, of course, is that the gasses used in the experiment “mimic” the atmosphere. The text further corroborates this, stating: “Miller’s experimental setup (Figure 3.1) was designed to produce a microcosm of ancient Earth. The large flask represented the atmosphere and contained the gases methane ( $\text{CH}_4$ ), ammonia ( $\text{NH}_3$ ), and hydrogen ( $\text{H}_2$ ).” (p. 39) There is no suggestion in the text that the atmosphere or conditions tested in the experiment were wrong. **Grade: F.**

*Darwin’s Tree of Life:* The textbook states: “The theory of evolution by natural selection predicts biologists should be able to reconstruct a tree of life—a family tree of organisms. If life on earth arose just once, then such a diagram would describe the genealogical relationships between species with a single, ancestral species at its base.” (pp. 5-6) It also contains a diagram showing

that all animals share a “common ancestor.” (p. 477) This hypothesis is treated as fact. It mentions the Cambrian explosion but does not pose it as a challenge to neo-Darwinian evolution. **Grade: D.**

*Homology in Vertebrate Limbs:* The textbook defines homology in terms of common ancestry, stating: “homology is a similarity that exists in species because they both inherited the trait from a common ancestor,” (p. 420) and “[h]omology (literally, ‘same-source’) occurs when traits are similar due to shared ancestry.” (p. 475) However, the textbook uses a circular argument by defining homology as evidence for common ancestry, stating: “HOMOLOGY IS EVIDENCE OF DESCENT FROM A COMMON ANCESTOR.” (p. 420) The textbook does not mention evidence that does not fit the claim. The textbook uses homology not just as an argument for evolution, but as an attack on the religious belief of special creation: “The theory of evolution predicts that homologies will occur. If species were created independently of one another, as the theory of special creation claims, these types of similarities would not occur.” (p. 421) **Grade: F.**

*Haeckel’s Embryos:* The textbook uses embryo photos rather than drawings, but it selectively portrays stages which are claimed to fit the theory. (p. 420) It fails to mention that earlier stages are dissimilar, stating: “The early embryonic stages of a chick, a human, and a cat, showing a strong resemblance.” (p. 420) It uses the term “gill pouches” rather than “gill slits”; “early chick, human, and cat embryos have tails and structures called gill pouches.” (p. 420) It uses these similarities for common ancestry, stating: “gill pouches and tails exist in chicks, humans, and cats because they existed in the fishlike species that was the common ancestor of today’s vertebrates.” (p. 420) **Grade: D.**

*Archaeopteryx:* The textbook postures *Archaeopteryx* as a transitional form, stating: “Feathers and wings gave some dinosaurs the ability to fly,” and that “[t]he dinosaur in Figure 27.13d, *Archaeopteryx*, was covered with complex feathers and could probably fly, at least short distances.” (p. 486) There is no mention of the fact that modern birds are probably not descended from it, and it does not hint at controversy over its transitional status. **Grade: F.**

*Peppered Moths:* N/A.

*Darwin’s Finches:* The textbook does not claim that the finches played a major role in the development of Darwin’s theory. However, it cites them as a good example of “evolution in response to natural selection.” (p. 826) It states that the beaks grew in size during a drought: “On average, survivors tended to have much deeper beaks than did the birds that died ... In only one generation, natural selection led to a measurable change in the characteristics of the population. Alleles that led to the development of deep beaks had increased in frequency in the population.” (pp. 427-428) Then it notes that the beak size returned to normal when the drought ended: “During this interval, small pointed beaks had exceptionally high reproductive success—meaning that they had higher fitness. As a result, the characteristics of the beaks changed again. Alleles associated with small, pointed beaks increased in frequency.” (p. 428) It later states: “Individuals with deep beaks are better able to crack the large fruits that predominate during drought years, while individuals with small beaks are better able to harvest the small seeds that predominate during wet years.” (p. 806) **Grade: C.**

*Whales:* The textbook shows pictures of various alleged intermediates between land-mammals and whales (p. 423). It does not mention that the fossils may have been interpreted under an

evolutionary bias. It does list the ages of some of the fossils as 50 to 47 mya, but it does not make any direct mention of the overall timescale available for the transition. It does not make any criticisms of claims that this transition took place in a short timeframe. However, because it does make some mentions of timing and ages of fossils, it will receive a D-. **Grade: D-**

*Junk-DNA:* The textbook promotes the notion of noncoding DNA stating: “When noncoding and repeated sequences were discovered, they were initially considered ‘junk’ DNA that was nonfunctional and probably unimportant and uninteresting. But subsequent work has shown that many of the repeated sequences observed in eukaryotes are actually derived from sequences known as transposable elements.” (p. 365) However, it classifies transposable elements as nonfunctional: “A transposable element is an example of what biologists call a selfish gene: a DNA sequence that survives and reproduces but does not increase the fitness of the host genome. Transposable elements and viruses are classified as parasitic because it takes time and resources to copy them along with the rest of the genome and because they can disrupt gene function when they insert in a new location. As a result, they decrease their host’s fitness.” (p. 365) It then calls LINE sequences “selfish genes” where most “do not actually function.” (p. 365) It further states, “For example, a mutation could produce a stop codon in the middle of an exon. A member of a gene family that resembles a working gene but does not code for a functional product, due to early stop codons, is called a pseudogene. Pseudogenes have no function.” (p. 368) Thus pseudogenes are said to provide evidence for evolutionary mutations and have no function. There is no suggestion that junk-DNA or non-coding or “parasitic DNA” DNA might have a useful function for the organism. **Grade: F.**

#### Other Notes:

Like many others, this textbook quotes Theodosius Dobzhansky stating, “Nothing in biology makes sense except in the light of evolution.” (p. 494) It also enters into debates over religious viewpoints. First, it prefers a pro-evolution religious view, stating: “The vast majority of biologists and religious leaders … see no conflict between evolution and religious faith.” (p. 8) Second, it frames its chapter presenting evidence in favor of evolution as negating certain religious viewpoints. For example, it states: “The take-home message is that species are dynamic—not static, unchanging, and fixed types, as claimed by Plato, Aristotle, and the theory of special creation.” (p. 418) “The theory of evolution by natural selection predicts that homologies will occur. If species were created independently of one another, as the theory of special creation claims, these types of similarities would not occur.” (p. 421) **Overall Grade: F.**

#### **8. Douglas J. Futuyma, *Evolution* (Sinauer, 2005).**

#### Icons Grading Notes:

*The Miller-Urey Experiment:* Contains Miller-Urey apparatus picture. Misleading caption states: “The apparatus Miller used to simulate the conditions of the early Earth.” (p. 93) No qualification of this error in the text. **Grade: F.**

*Darwin’s Tree of Life:* In a chapter titled, “The Tree of Life: Classification and Phylogeny,” this textbook states, “By this process of branching and modification, repeated innumerable times over the course of many millions of years, many kinds of organisms have evolved from a single ancestral organisms at the very base, or root, of the tree.” (p. 18) This hypothesis is treated as fact. It mentions the Cambrian explosion (p. 97-98), but not as a challenge to neo-Darwinian

evolution. In fact, it states, “A combination of genetic and ecological causes may account for this diversification.” (p. 98) **Grade: D.**

*Homology in Vertebrate Limbs:* The textbook defines homology in terms of common ancestry, stating: “In the previous examples, each character changed only across the whole phylogeny. Hence all the taxa sharing a character state inherited it without change from their common ancestor. Such a character state is said to be homologous in all the taxa that share it.” (p. 23) It later states: “related organisms have homologous characters, which have been inherited (and sometimes modified) from an equivalent organ in the common ancestor.” (p. 49) However, it then uses homology as “Evidence for Evolution,” stating: “2. Homology. Similarity of structure despite differences in function follows from the hypothesis that the characteristics of organisms have been modified from the characteristics of their ancestors … the nearly universal, arbitrary genetic code [] makes sense only as a consequence of common ancestry.” (p. 48) There is no mention of evidence that challenges common ancestry, and in fact it states, “Since Darwin’s time, the amount of comparative information has increased greatly, and today includes data not only from the traditional realms of morphology and embryology, but also from cell biology, biochemistry, and molecular biology.” (p. 49) **Grade: F.**

*Haeckel’s Embryos:* N/A. This textbook states that “Early in development, human embryos briefly display branchial pouches similar to the gill slits of fish embryos.” (p. 48) However, it does not contain any diagrams or enough information on this topic overall to evaluate this icon. It also has a chapter titled “Evolution and Development,” but this chapter also does not use vertebrate embryo comparisons as an argument for evolution.

*Archaeopteryx:* The textbook names *Archaeopteryx* an “intermediate,” calling it “one of the most famous non-missing links of all time.” (p. 74) The textbook mentions no controversy over the ancestral status of *Archaeopteryx*, nor does it mention any dissenting scientific viewpoints or controversy regarding the view that birds evolved from theropod dinosaurs. The textbook does contain a diagram on page 76 which implies that *Archaeopteryx* was not a direct ancestor of modern birds, but this point is not made in the text. **Grade: C-.**

*Peppered Moths:* The textbook discusses the Peppered Moth story, using staged photographs that purport to show the moths “on a dark tree trunk” and then on “a pale tree trunk.” (p. 293) There is no mention that the photos are staged or that moths don’t normally rest on tree trunks. Rather, it states that “[t]here is considerable evidence, obtained by several independent researchers, that birds attack a greater proportion of gray than black moths where tree trunks, due to air pollution, lack the pale lichens that would otherwise cover them.” (p. 293) There is no mention of any problems with the classical stories. **Grade: F.**

*Darwin’s Finches:* The textbook calls the Galápagos finches an example of adaptive radiation: “The most famous example is the adaptive radiation of Darwin’s finches in the Galápagos archipelago.” (p. 62) The textbook mentions the famous study on how beak sizes responded to changes in seeds during a drought: “Selection strongly favored birds that were larger and had deeper bills because they could more effectively feed on large, hard seeds, virtually the only available food.” (p. 309) There is no mention that beak sizes returned to normal after the drought. In fact, diagram 13.11, which shows beak size over time, terminates after the drought and does not show what happened. The textbook does not claim that Darwin relied on the finches when developing his theory. Thus, the best grade it can receive is a D. **Grade: D.**

*Whales:* The textbook shows drawings of various alleged intermediates between land-mammals and whales (p. 79). It does not mention that the claims about the fossils might be the result of evolutionary interpretation. It does mention that they lived from 50 – 35 mya, but this overestimates the actual timescale by over 50%. It does not make any criticisms of the ability of this transition to occur in such a short timescale. However, because it does mention something about the timeline, it will receive a D-. **Grade: D-.**

*Junk-DNA:* The book uses noncoding DNA as an argument against intelligent design and for evolution: “Because natural selection consists only of differential reproductive success, it results in ‘selfish genes’ and genotypes, some of which have results that are inexplicable by intelligent design. We have seen that genomes are brimming with sequences such as transposable elements that increase their own numbers without benefitting the organism. Such conflicts among genes in a genome are widespread. Are they predicted by intelligent design theory? Likewise, no theory of design can predict or explain features that we ascribe to sexual selection, such as males that remove sperm of other males from the female’s reproductive tract, or chemicals that enhance a male’s reproductive success but shorten his mate’s life span.” (p. 531) It states that pseudogenes are “a non functional DNA sequence,” (p. 28) and “[i]n eukaryotes, the vast majority of DNA has no apparent function. Only 28% of the human genome is thought to be transcribed, and much of this consists of introns, so less than 5% (a generous estimate) of the genome encodes proteins. At least 45 percent of the human genome consists of repeated sequences, amounting to as many as 4.3 million repetitive elements that are repeated sequences of a few bp each.” (pp. 163-164) Its main statement asserts: “Eukaryotic genomes—particularly those of mammals, amphibians, and some plants—are by comparison large and lumbering, harboring vast regions of noncoding and repeated DNA sequences with unknown functions. Although much of this noncoding DNA is unlikely to be ‘junk’(as was postulated in the early 1970s), a typical mammalian genome is by any measure extravagant in its excesses and complexity compared to a bacterial genome. … Only about 1.5 percent of the human genome, for example, is composed of protein-encoding sequences. Up to 95% of a typical human gene consists of introns. Moreover, there are vast regions of noncoding DNA, much of which may be ‘selfish DNA’ that merely replicates itself and accumulates within genomes. However, more than 10 percent of noncoding DNA is highly conserved between long-diverged species, such as humans and mice, suggesting a function maintained by purifying selection. … “ (p. 456) This textbook clearly tries to claim that much noncoding DNA is junk, and therefore evidence for evolution. But because it suggests that there may be some function for at least some noncoding DNA, it will receive a D+. **Grade: D+.**

#### Other Notes:

This textbook is different from the other textbooks evaluated here as it is a college level text that is solely devoted to the topic of evolution. Wells’ 2000 review assessed the previous textbook by this author, Futuyma’s 1998 edition of *Evolutionary Biology*. It also quotes Dobzhansky, stating: “The evolutionary perspective illuminates every subject in biology, from molecular biology to ecology. Indeed, *evolution is the unifying theory of biology*. ‘Nothing in biology makes sense,’ said the geneticist Theodosius Dobzhansky, ‘except in the light of evolution.’” (p. 1, emphasis in original) It goes out of its way to attack intelligent design (ID) extensively, making essentially incoherent arguments that ID is both unfalsifiable and falsified by the evidence. Claiming ID is unfalsifiable, the textbook states that ID “generates no research ideas,” that science “cannot judge the validity” of ID’s claims, and that ID “cannot be evaluated by the methods of science.” (pp. 526-527) Yet the textbook also explicitly attempts to refute ID, stating, “Darwin and

subsequent evolutionary biologists have described innumerable examples of biological phenomena that are hard to reconcile with beneficent intelligent design,” (p. 530) and claiming that “‘accidents’ of evolutionary history explain many features that no intelligent engineer would be expected to design.” (p. 49) It even includes a section titled “Failures of the argument from design” (p. 529) which cites supposed examples of bad design (which are highly controversial<sup>xiii</sup>). After boasting about the purported evidence for evolution, it states: “Contrast this mountain of evidence with the evidence for supernatural creation or intelligent design: *there is no such evidence whatever.*” (p. 532, emphasis in original) There’s nothing wrong with a textbook offering critiques of ID, but this textbook does not even pretend to maintain objectivity in that endeavor. The textbook states that “the historical reality of evolution—the descent with modification of all organisms from common ancestors—has not been in question among scientists for well over a century. It is as much a scientific fact as the atomic constitution of matter or the revolution of the Earth around the Sun.” (p. 523) Ironically, the textbook later states, “Science is tentative.” (p. 542) If only it applied such thinking to neo-Darwinian evolution. **Overall Grade: D-.**

## **9. George B. Johnson, *Essentials of the Living World* (McGraw Hill, 2006).**

### Icons Grading Notes:

*The Miller-Urey Experiment:* This textbook does not contain a picture of the Miller-Urey apparatus, but it does discuss the experiment. It states that Miller and Urey “reconstructed the oxygen-free atmosphere of the early earth in their laboratory,” and thus suggests the experiment was accurate (p. 291) However, it notes that “[r]ecently, concerns have been raised regarding the ‘primordial soup’ hypothesis” noting that the atmosphere may not have had ammonia and methane. (p. 291) Instead it promotes an obscure “bubble hypothesis,” where supposedly methane, ammonia, amino acids, and other needed properties might have been present. While it acknowledges some problems with Miller-Urey, it leaves the student with the impression that a variant of Miller-Urey could have worked. **Grade: C.**

*Darwin’s Tree of Life:* This textbook treats the tree of life as uncritical fact, asserting there is “[a] tree of life” and “evolutionary relationships among the three domains” of life, including a “common ancestor” of all three domains. (p. 283) The term “Cambrian explosion” is not used, but it does note that “[v]irtually all of the major groups of animals that survive at the present time originated in the sea at the beginning of the Paleozoic era, during or soon after the Cambrian period.” (p. 347) On page 17 it shows a tree that relates all living organisms into one “tree of life.” **Grade: D.**

*Homology in Vertebrate Limbs:* The textbook defines homology in terms of common ancestry: “For example, the forelimbs of vertebrates are all homologous structures; that is, although the structure and function of the bones have diverged, they are derived from the same body part present in a common ancestor.” (p. 252) However, it also suggests this evidence reveals common ancestry, stating: “As vertebrates evolved, the same bones are sometimes put to different uses, yet they can still be seen, their presence betraying their evolutionary past.” (p. 252) No evidence that does not fit with homology is mentioned. **Grade: F.**

*Haeckel’s Embryos:* This textbook uses photos rather than drawings, but they are selectively chosen to show a particular stage of development. No mention is made that earlier stages of embryos are dissimilar. It claims that human embryos have “gill slits.” (p. 252) **Grade: D.**

*Archaeopteryx*: The textbook calls *Archaeopteryx* a “transitional bird” and a “fossil link between reptiles and birds.” (p. 45; see also p. 352) It does not mention any controversy over its transitional status nor does it mention controversy over the hypothesis that birds are descended from dinosaurs. **Grade: F.**

*Peppered Moths*: This textbook shows staged photos of peppered moths, which it admits were “glued to the trunk of a soot-polluted tree.” (p. 247) It even explains that “[f]urther work showed these moths don’t spend their days on tree trunks.” It also notes that the classical explanation may be wrong: “So I camouflage the reason natural selection favored the dark moths?” (p. 247) **Grade: C.**

*Darwin’s Finches*: The textbook calls the Galápagos finches an example of “adaptive radiation” (p. 30) and states that “the Galápagos finches gave Darwin valuable clues about how natural selection shapes the evolution of species.” (p. 21) “Darwin observed 14 different species of finches on the Galápagos Islands … and surmised that the very different shapes of their bills represented evolutionary adaptations,” (p. 24) and “Darwin’s Galápagos finches played a key role in his argument for evolution by natural selection.” (p. 27) It does note that after the rain returned, “[i]n wet years, when many small seeds were available, smaller beaks became more common.” (p. 29) **Grade: D.**

*Whales*: The textbook cites “Whale ‘missing links’” (p. 250) and shows reconstructions of the fossils. There is no mention that reconstructions may be subject to evolutionary interpretation. It does note that the fossils “occurred in the Eocene period, from 45 to 55 million years ago” but does not specifically state that only 10 million years were allowed for the transition. (p. 250) But because it does suggest that there were only 10 million years, it will receive a D-. **Grade: D-**.

*Junk-DNA*: The textbook suggests without qualification that much of the genome is junk, stating that introns are “extraneous ‘extra stuff,’” and “only 1% to 1.5% of the genome is devoted to the exons that encode proteins, while 24% is devoted to the noncoding introns.” (p. 210) **Grade: F.**

#### Other Notes:

Most biology textbooks cover evolution in a unit somewhere in the middle of the book. Not this one—it goes out of its way to push Darwinian evolution in its first pages and then devotes Chapter 2 to covering “Evolution and Ecology”—even though students have not yet even encountered the book’s chapter on the chemistry of life. It states that “Darwin’s theory of evolution by natural selection is almost universally accepted by scientists” (p. 38) and then recommends that students read online articles by the author, such as “Answering evolution’s critics” or “Darwinism at the cellular level.” The latter article in particular attacks ID, stating: “The evolution of complex cellular machinery reflects natural selection, not intelligent design.” Later the book claims that “Biologists do not agree” with the “intelligent design argument.” (p. 269) Again, textbooks are welcome to critique ID, but this was not done in an evenhanded fashion. **Overall Grade: D-.**

**10. Sylvia S. Mader, *Essentials of Biology* (McGraw Hill, 2007).**

Icons Grading Notes:

*The Miller-Urey Experiment:* N/A.

*Darwin's Tree of Life:* The textbook treats common descent as an uncritical fact, stating, “Many lines of evidence consistently support the hypothesis that organisms are related through common descent. A hypothesis becomes a scientific theory only when a variety of evidence made by independent investigators supports the hypothesis. The theory of evolution is a unifying principle in biology because it can explain so many different observations in various fields of biology. The theory of evolution has the same status in biology that the germ theory of disease has in medicine.” (p. 224) It mentions the Cambrian explosion in the body of the text (pp. 253, 307), but it does not mention how it challenges neo-Darwinism. **Grade: D.**

*Homology in Vertebrate Limbs:* The textbook defines homology as similarity due to inheritance from a common ancestor, but it then in a circular fashion uses homology as evidence for common ancestry. The textbook thus defines homology: “Anatomically similar structures explainable by inheritance from a common ancestor are called homologous structures” (p. 226). It then says regarding similarities in vertebrate limb bones, “This unity of plan is evidence of a common ancestor.” (p. 226) The textbook further states, “Anatomical and developmental homologies are independent evidence of a shared common ancestor and an evolutionary relationship between groups of organisms.” (p. 226) There is no mention of evidence that does not fit with evolution’s claims regarding homology. **Grade: F.**

*Haeckel's Embryos:* The textbook uses photos rather than drawings, but the photos are selectively taken from the so-called pharyngular stage (p. 226). It gives no hint that embryos are dissimilar in earlier stages. **Grade: D.**

*Archaeopteryx:* The textbook presents *Archaeopteryx* as the transitional link between dinosaurs and modern birds, stating that the fossils are “intermediate between reptiles and birds.” (p. 224) It does not point out that modern birds are probably not descended from it and does not hint that there is controversy over its ancestry or transitional status. **Grade: F.**

*Peppered Moths:* The textbook uses staged photos without hinting that they misrepresent the natural situation. It attributes the changes to natural selection, and it gives no hint that there are problems with the classical story (pp. 234-235). **Grade: F.**

*Darwin's Finches:* The textbook describes the Galápagos finches as a good example of adaptive radiation, stating, “One of the best examples of speciation through adaptive radiation is provided by the finches on the Galápagos Islands, which are often called Darwin’s finches because Darwin first recognized their significance as an example of how evolution works.” (p. 251) The textbook thus also implies that the finches played an important role in the formulation of Darwin’s theory. It makes no mention of the fact that selection on the finches oscillates between dry and wet seasons. **Grade: F.**

*Whales:* The textbook mentions the whale sequence and shows common drawings of fossils (p. 224) but says nothing about the limited amount of time available for this transition. In fact, the diagram (14.12) misleadingly and inaccurately implies that the evolution of whales took over 40

million years, from around 60 mya to around 10 or 20 mya. It also does not note that fossil reconstructions may be based upon evolutionary interpretation and not hard data. **Grade: F.**

*Junk-DNA:* N/A.

*Other Notes:*

This textbook demands not just that students learn about evolution, but that they assent to it. On page 225 it asks, “Explain why evolution is no longer considered a hypothesis?” and provides the answer: “Evolution is supported by many diverse and independent lines of evidence.” Then on page 229 it offers a multiple choice question where students are forced to answer that evolution is supported by multiple lines of evidence:

10. Evolution is considered a

- a. hypothesis because it is supported by data from the fossil record.
- b. hypothesis because it is supported by multiple types of data.
- c. theory because it is supported by data from the fossil record.
- d. theory because it is supported by multiple types of data.

Of course from the question on page 225 we know the correct answer here is intended to be “d,” which forces students to claim that evolution is “supported by multiple types of data.” Yet each answer choice forces students to claim that evolution is “supported.” The student is not allowed to express scientific dissent from neo-Darwinian evolution. **Overall Grade: F.**

**11. Sylvia S. Mader, *Biology* (McGraw Hill, 10<sup>th</sup> ed., 2010).**

*Icons Grading Notes:*

*The Miller-Urey Experiment:* Contains Miller-Urey apparatus picture. The caption and text mislead students to think the atmosphere contained methane and ammonia (pp. 318-319). The caption states: “Gasses that were thought to be present in the early Earth’s atmosphere were admitted to the apparatus...” (p. 318) The text provides a slight qualification: “Whereas inert nitrogen gas ( $N_2$ ) would have been abundant in the primitive atmosphere, ammonia ( $NH_3$ ) would have been scarce.” (p. 319) However, the text then goes on to claim that “ammonia would have been plentiful at hydrothermal vents,” (p. 319) making no discussion of whether Miller-Urey experiments work in the deep sea environments, a location not notorious for being subject to lightning strikes. **Grade: D.**

*Darwin’s Tree of Life:* The textbook treats common descent as an uncritical fact, stating, “Many different lines of evidence support the hypothesis that organisms are related through common descent,” (p. 276) and “[t]he hypothesis that organisms share a common descent is supported by many lines of evidence. The fossil record, biogeography, anatomical evidence, and biochemical evidence all support the hypothesis.” (p. 280) It mentions the Cambrian explosion in the body of the text (pp. 327-328), but it does not mention how it challenges neo-Darwinism. **Grade: D.**

*Homology in Vertebrate Limbs:* The textbook defines homology as resulting from common ancestry, stating: “Structures that are anatomically similar because they are inherited from a common ancestor are called homologous structures.” (p. 278) However, it then uses this

evidence to argue for common ancestry, stating: “The most plausible explanation for this unit is that this basic forelimb plan belonged to a common ancestor.” (p. 278) **Grade: F.**

*Haeckel’s Embryos:* The textbook uses a slightly redrawn and colorized version of Haeckel’s embryo drawings with only slight alterations and states, “At these comparable developmental stages, vertebrate embryos have many features in common, which suggests they evolved from a common ancestor.” (p. 278) No mention is made of differences in early stages of vertebrate embryonic development. Rather, the textbook declares, “All vertebrates inherited the same developmental pattern from their original common ancestor.” (p. 278) **Grade: F.**

*Archaeopteryx:* The textbook calls *Archaeopteryx* a “transitional link between dinosaurs and birds” and an “intermediate between dinosaurs and birds” (p. 276), and there is no mention of controversy over the ancestral status of *Archaeopteryx* or the hypothesis that birds evolved from dinosaurs. **Grade: F.**

*Peppered Moths:* The textbook uses staged photos and tells a story of how melanic moth frequencies shifted during the industrial revolution because “birds that eat moths are less likely to see light-colored moths against the light vegetation” and “birds are less likely to see dark-colored moths against dark vegetation.” (pp. 275, 286). No mention is made of problems with the classical story. **Grade: F.**

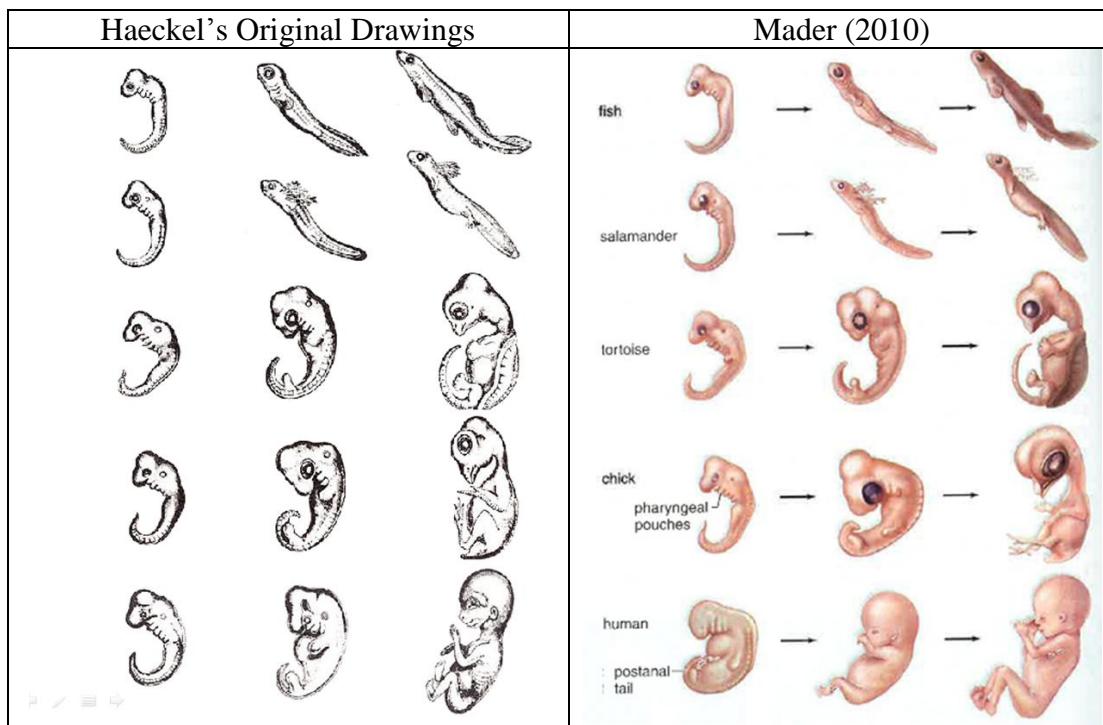
*Darwin’s Finches:* The textbook calls finches an example of “adaptive radiation” (p. 306) and textbook states the finches played a major role in the development of Darwin’s theory: “Darwin almost overlooked the finches because of their unassuming nature compared with many of the other animals in the Galápagos. However, these birds would eventually play a major role in his thoughts about geographic isolation. The finches of the Galápagos Islands seemed to Darwin like mainland finches, but they exhibited significant variety with regards to their beaks. … Later, Darwin speculated as to whether these different species of finches could have descended from a type of mainland finch.” (p. 270) “Darwin had formed his natural selection hypothesis by observing the distribution of tortoises and finches on the Galápagos Islands.” (p. 275) It also implies that there was unidirectional selection in the finches, stating: “In times of drought, when only large seeds were available, birds with larger beaks were favored.” (p. 295) There is no mention of oscillating selection leading beak sizes to revert after the drought. **Grade: F.**

*Whales:* The textbook says that “transitional fossils” are “evidence that whales evolved from land-based ancestors.” (p. 276) Fossil reconstructions are shown (p. 276, 300), but no mention is made that there may be evolutionary interpretation of these fossils. Moreover, there is no mention of the short timescale of whale evolution or any problems with neo-Darwinian evolution of this transition. **Grade: F.**

*Junk-DNA:* This textbook states that much non-coding DNA may have function: “Recently, scientists observed that between 74% and 93% of the genome is transcribed into RNA, including many of these unknown sequences. Thus, what was once thought to be a vast junk DNA wasteland may be much more important than once thought and play active roles in the cell.” (p. 257) However, it does not note that junk-DNA paradigm was the result of evolutionary thinking, instead implying that Darwinian selection caused them to suspect function for non-coding DNA. As a result, it gets not a C but a C-. **Grade: C-.**

Other Notes:

This 2010 textbook is particularly bad in that it uses a slightly altered and colorized redrawing of Haeckel's original embryo drawings, and states: "At these comparable developmental stages, vertebrate embryos have many features in common, which suggests they evolved from a common ancestor."<sup>xiv</sup> Consider the diagram below comparing Haeckel's original drawings (left) to Mader's figure (right):



**Overall Grade: F.**

**12. Sylvia S. Mader, Jeffrey A. Isaacson, Kimberly G. Lyle-Ippolito, Andrew T. Storfer, *Inquiry Into Life* (13<sup>th</sup> ed., McGraw Hill, 2011).**

Icons Grading Notes:

**The Miller-Urey Experiment:** The textbook contains a graphic showing the Miller-Urey experiment and the caption states "Gases that were thought to be present in the early Earth's atmosphere were admitted to the apparatus..." (p. 543). The text itself even states that methane and ammonia were spewed into the early earth's atmosphere: "In the early Earth, volcanoes erupted constantly, and the first atmospheric gases would have consequently contained methane ( $\text{CH}_4$ ), ammonia ( $\text{NH}_3$ ), and hydrogen ( $\text{H}_2$ ).” (p. 542) There is no mention of the experiment's flaws, and no indication in the text that these gases were not present on the early earth. **Grade: F.**

**Darwin's Tree of Life:** The textbook treats the tree of life hypothesis as a fact, showing diagrams showing organisms are related without any skepticism whatsoever (pp. 550, 564, . It states: "Because of descent with modification, all living things share the same fundamental characteristics: they are made of cells, take chemicals and energy from the environment, respond to external stimuli, and reproduce.... Many fields of biology provide evidence that evolution through descent with modification occurred in the past and is still occurring.” (p. 545) While a

geological timescale does show the Cambrian period and notes that this is when invertebrate phyla appear (p. 546), there is no mention of the Cambrian explosion. **Grade: F.**

*Homology in Vertebrate Limbs:* This textbook provides a classic example of the circular reasoning used to support common ancestry through homology. The textbook defines homology as follows: “Structures that are inherited from a common ancestor are called homologous structures.” (p. 549) It then uses homology as evidence for common ancestry: “Homologous structures provide evidence of a common ancestor.” (p. 549) It does not cite any evidence that does not fit with homology. **Grade: F.**

*Haeckel’s Embryos:* The textbook uses a slightly redrawn and colorized version of Haeckel’s embryo drawings with only slight alterations and states, “At these comparable developmental stages, vertebrate embryos have many features in common, which suggests they evolved from a common ancestor.” (p. 549) It does note that “These embryos are not drawn to scale” (p. 549) but no details are given about actual differences between embryos. **Grade: F.**

*Archaeopteryx:* In a caption titled “Transitional fossils,” the textbook states *Archaeopteryx* “has features of both birds and dinosaurs.” (p. 545) The text states “The fossil clearly seems to be an intermediate form between dinosaurs and birds.” (p. 545) It calls it “the first bird” (p. 545) but does not point out that modern birds are probably not descended from it, and does not hint at any controversy over its ancestry or transitional status. **Grade: F.**

*Peppered Moths:* The textbook contains staged drawing with photos showing, with the drawing showing light and dark moths next to light and dark tree trunks. It states: “(Left) Light-colored moths are more frequent in the populations because birds that eat moths are less likely to see light-colored peppered moths against light vegetation. (Right) Dark-colored moths are more frequent in the population because birds are less likely to see dark-colored moths against dark vegetation.” (p. 552) It does not mention Kettlewell by name but asserts the classic results of his experiments as true, stating “Predatory birds are the selective agent that causes the makeup of the populations to vary. When dark-colored moths rest on light trunks in a nonpolluted area, they are seen and eaten by these birds. With pollution, the trunks of trees darken, so light-colored moths stand out and are eaten more than dark-colored moths. … evolution has occurred because a selective force (predatory birds) favored one genotype over another.” (p. 552) It thus has all the elements of the inaccurate claims about Kettlewell’s classical experiments but mentions no flaws in these conclusions. **Grade: F.**

*Darwin’s Finches:* N/A. The textbook states “Darwin’s finches are an example of adaptive radiation” (p. 561) but does not discuss studies showing that beak sizes changed in response to climate. As a result, there is not enough information to evaluate this icon.

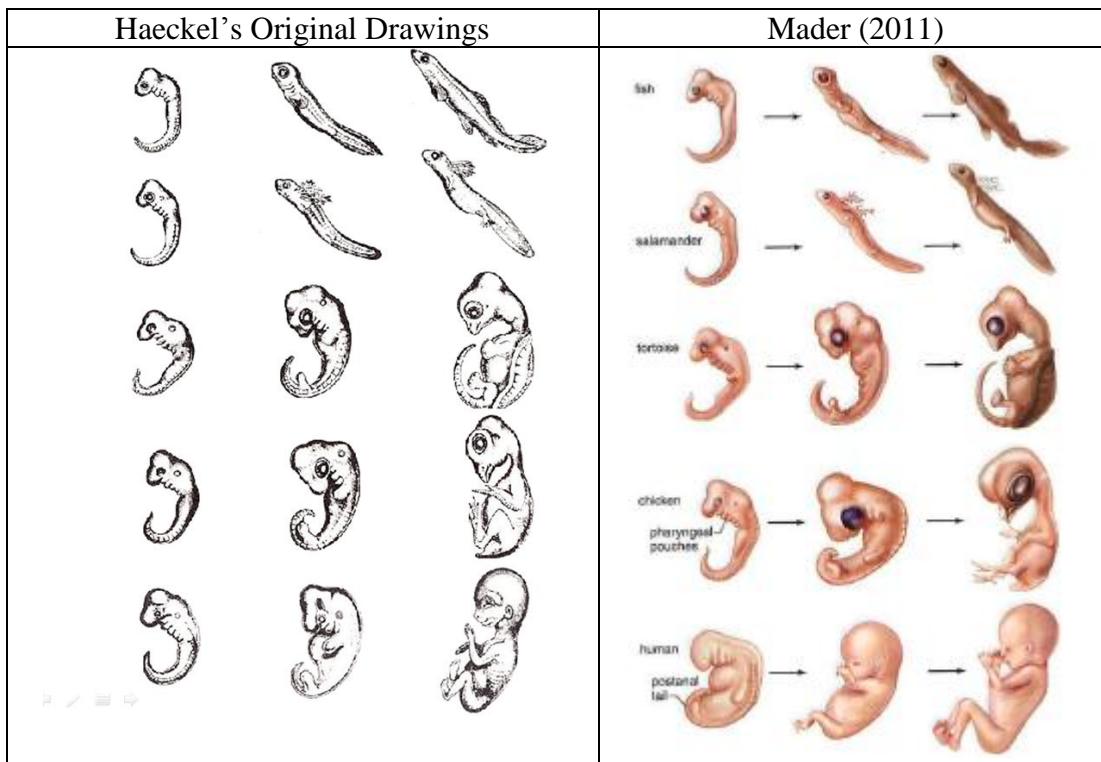
*Whales:* The textbook states that “In recent years the fossil record has yielded an incredible parade of fossils that link modern whales and dolphins to land ancestors.” (p. 549) It shows a reconstruction of *Ambulocetus* but does not mention that some evolutionary interpretation may have gone into the reconstruction. Moreover, it mentions the age of *Ambulocetus* (“50 MYA”) but says nothing about the overall rapid timeline in which whales evolved or problems that might pose for neo-Darwinian evolution. **Grade: F.**

*Junk-DNA:* The textbook notes that much junk-DNA is now thought to have function: “noncoding DNA, once dismissed as ‘junk DNA,’ is now thought to serve many important

functions and has piqued the curiosity of many investigators.” (p. 534) It further notes that some noncoding DNA “is transcribed into ribosomal RNA and transfer RNA” and “The rest of the genome is comprised of transposable elements (or transposons), repetitive DNA elements, and sequences with unknown function” and “a transposon sometimes acts like a regulator gene.” (p. 534) It goes on to say regarding repetitive elements that “Although many scientists still dismiss them as having no function, others point out that the centromeres and telomeres of chromosomes are composed of repetitive elements and, therefore, repetitive DNA elements may not be as useless as once thought.” (p. 534) Regarding introns, it notes that “The presence of introns allows exons to be put together in various sequences so that different mRNAs and proteins can result from a single gene.” (p. 535) It does not note that junk DNA thinking came from neo-Darwinism or that it has hindered research. **Grade: C.**

Other Notes:

The textbook takes a dogmatic approach to the natural chemical origin of life stating “the very first life had to come from nonliving chemicals.” (p. 542) It also promotes the cytochrome c tree as being consistent with the standard phylogeny, stating “These biochemical data are consistent with those provided by a study of the fossil record and comparative anatomy.” (p. 550) Such cherry picking of data ignores conflicts between trees, such as the cytochrome b tree. As one article in *Trends in Ecology and Evolution* reported: “[T]he mitochondrial cytochrome b gene implied . . . an absurd phylogeny of mammals.”<sup>xv</sup> It states that “Our understanding of evolutionary biology has helped doctors treat patients” (p. 565) when dealing with antibiotic resistance, ignoring that doctors actually fight antibiotic resistance by relying on the fact that there are *limits* to how much microorganisms can evolve. It dogmatically states “The fossil record and biogeography, as well as studies of comparative anatomy and development, and biochemistry, all provide evidence for evolution” (p. 566) – ignoring much data that is contrary to these claims. It states that “All organisms have certain biochemical molecules in common, and these chemical similarities indicate the degree of relatedness” (p. 566), again ignoring contrary data. Finally, this 2011 textbook provides another example that uses recolorized and slightly redrawn versions of Haeckel’s inaccurate drawings:



**Overall Grade: F.**

**13. Kenneth R. Miller and Joseph Levine, *Biology* (Prentice Hall, 2008) (Teacher's Edition).**

Icons Grading Notes:

*The Miller-Urey Experiment:* Contains Miller-Urey apparatus picture. The caption misleads students to think the atmosphere contained methane and ammonia, stating: "This and other experiments suggested how simple compounds found on the early Earth could have combined to form the organic compounds needed for life." (p. 424) The text, however, gives a slight qualification, though it is still misleading: "Miller and Urey's experiments suggested how mixtures of the organic compounds necessary for life could have arisen from simpler compounds present on a primitive Earth. Scientists now know that Miller and Urey's original simulations of Earth's atmosphere were not accurate." Amazingly, though the text suggests that the atmosphere was "not accurate," the teachers' instructions in the margin states "Ask: Why did Miller and Urey use a mixture of nitrogen, hydrogen, methane and ammonia in their apparatus? (Because this mixture of gases resembles Earth's early atmosphere)." (p. 424) So the text and the caption and the teachers' notes expressly contradict one-another. The text does contain the helpful comment, however, that "[a] stew of organic molecules is a long way from a living cell and the leap from nonlife to life is the greatest gap in scientific hypotheses of Earth's early history." (p. 425) **Grade: D-.**

*Darwin's Tree of Life:* The textbook treats common descent as an uncritical fact, stating, "If we look far enough back, the logic concludes, we could find the common ancestor of all living things. This is the principle known as common descent. According to this principle, all species—living and extinct—were derived from common ancestors. Therefore, a single 'tree of

life' links all living things." (p. 382) It mentions the Cambrian explosion in the body of the text (pp. 430, 746), but it does not mention how it challenges neo-Darwinism. **Grade: D.**

*Homology in Vertebrate Limbs:* This textbook cites homology as relating to structure and development but then cites it as evidence for common ancestry. It states: "Structures that have different mature forms but develop from the same embryonic tissues are called homologous structures," and then it claims homology is evidence for common ancestry, stating: "Homologous structures provide strong evidence that all four-limbed vertebrates have descended, with modifications, from common ancestors." (p. 384) There is no mention of contrary data. **Grade: D.**

*Haeckel's Embryos:* The textbook uses photos rather than pictures, but the photos are selectively taken from one particular stage where they are similar (p. 385). The caption reads, "In their early stages of development, chickens, turtles, and rats look similar, providing evidence that they shared a common ancestry." (p. 385) The text states that "[t]he early stages, or embryos, of many animals with backbones are very similar." (p. 385) No mention is made that early stages are actually not similar. However, it notes that "the biologist Ernst Haeckel fudged some of his drawings to make the earliest stages of some embryos seem more similar than they actually are!" (p. 385) Since it notes that the early stages can be overstated, but nonetheless still misstates the nature of the actual similarities, it will receive a D+. **Grade: D+.**

*Archaeopteryx:* The textbook presents *Archaeopteryx* as a "transitional species with characteristics of both dinosaurs and birds," but it notes that, along with other fossils, "None of the animals are direct ancestors of modern birds." (p. 807) There is no mention that of controversy over claims that dinosaurs are the ancestors of birds. **Grade: C.**

*Peppered Moths:* N/A.

*Darwin's Finches:* The textbook states that finches are an example of "adaptive radiation" (p. 436). The textbook implies that the Galápagos finches played an important role in the formulation of Darwin's theory, stating: "some of the most important studies of natural selection in action involve descendants of the finches that Darwin observed in the Galápagos Islands. Those finch species looked so different from one another that when Darwin first saw them, he did not realize they were all finches. He thought they were blackbirds, warblers, and other kinds of birds. The species he examined differed greatly in the sizes and shapes of their beaks and in their feeding habits ... Some species fed on small seeds, while others ate large seeds with thick shells. ... Once Darwin realized that these birds were all finches, he hypothesized that they had descended from a common ancestor. Over time, he proposed natural selection shaped the beaks of different bird populations as they adapted to eat different foods." (p. 406) It makes no mention that beak sizes returned to normal after the drought, instead implying there was net change, stating: "average beak size in that finch population increased dramatically over time. This change in beak size is an example of directional selection operating on an anatomical trait." (p. 407) **Grade: F.**

*Whales:* N/A.

*Junk-DNA:* The textbook weakly suggests that noncoding DNA may have function, stating: "Why do cells use energy to make large RNA molecules and then throw parts of it away? That's a good question, and biologists still do not have a complete answer to it. Some RNA molecules

may be cut up and spliced in different ways in different tissues, making it possible for a single gene to produce several different forms of RNA. Introns and exons may also play a role in evolution. This would make it possible for very small changes in DNA sequences to have dramatic effects in gene expression.” (p. 302) However, since it does not claim that they are positively junk, it receives a D+. **Grade: D+.**

Other Notes:

Providing another example of the faux inquiry-based learning employed when teaching evolution, this textbook asks students, “Why do you think that birds evolved from dinosaurs?” tacitly implying that students are not permitted to think otherwise. (p. 807) The textbook likewise instructs teachers to “[e]xplain that scientists do not dispute the fact that evolution has occurred, because so much evidence supports it.” (p. 369) The textbook later presents a section titled “Strengths and Weaknesses of Evolutionary Theory,” (p. 386) but again this appears to be more faux-inquiry. The first sentence of this section states: “Scientific advances in many fields of biology, along with geology and physics, have confirmed and expanded most of Darwin’s hypotheses.” (p. 386) It seems that for these authors, “strengths and weaknesses” means there are strengths, but no weaknesses, are presented. **Overall Grade: D.**

**14. Kenneth R. Miller and Joseph Levine, *Biology* (Pearson, 2010).**

Icons Grading Notes:

*The Miller-Urey Experiment:* The textbook shows a drawing of Miller’s apparatus (p. 554) and claims it “suggested how mixtures of organic compounds necessary for life could have arisen from simpler compounds on a primitive Earth.” (p. 554) The text does say that “[o]ur knowledge of Earth’s early atmosphere has grown since Miller and Urey’s early work,” (p. 554) but it leaves it to the student to figure out that Miller was wrong to use methane and ammonia, since the actual earth’s atmosphere probably contained carbon dioxide, water vapor, and nitrogen. In fact, it suggests that even “accurate mixtures” can produce important biomolecules. (p. 554) **Grade: D.**

*Darwin’s Tree of Life:* The textbook treats common descent as an absolute fact, stating that “‘tree-thinking’ implies all organisms are related,” “[f]ar enough back are the common ancestors of all living things,” and “[a] single ‘tree of life,’ then, links all living things.” (p. 464) It further states that Darwin’s theory “unites all living things in a single tree of life.” (p. 447) It does mention the Cambrian explosion but does not mention how it challenges neo-Darwinism.

**Grade: D.**

*Homology in Vertebrate Limbs:* In contrast to the previous edition, this textbook contains a striking example of circularity in the definition of homology. In two consecutive sentences it first defines homology as resulting from inheritance from a common ancestor then states that homologous structures are evidence that the two organisms share a common ancestor. It thus states: “Structures that are shared by related species and have been inherited from a common ancestor are called homologous structures. According to evolutionary theory, organisms that share homologous structures have descended, with modification, from a common ancestor.” (p. 468) In fact, it further states that homologous structures can “help determine how recently species shared a common ancestor.” (p. 468) There is no mention of contrary data. **Grade: F.**

*Haeckel's Embryos:* This textbook does not fit the usual method of presenting embryological evidence for evolution in that it contains no photos or drawings at all, yet it also makes no mention that early vertebrate embryos are different. Instead, it presents a pro-evolution view of embryology that misrepresents the evidence, stating: “Researchers noticed a long time ago that the early developmental stages of many animals with backbones (called vertebrates) look very similar. Recent observations make clear that the same groups of embryonic cells develop in the same order and in similar patterns to produce many homologous tissues and organs in vertebrates. For example, despite the very different adult shapes and functions of limb bones, all those bones develop from the same clumps of embryonic cells. Evolutionary theory offers the most logical explanation for these similarities in patterns of development. Similar patterns of embryological development provide further evidence that organisms have descended from a common ancestor.” (p. 469) Despite the inaccurate statements given regarding embryology, because it does not use misleading drawings, it will receive a C-. **Grade: C-.**

*Archaeopteryx:* The textbooks presents *Archaeopteryx* as a transitional link between dinosaurs and modern birds, stating it and other fossils have “done a lot to ‘connect the dots’ between modern birds and their dinosaur ancestors” and that *Archaeopteryx* “was a bird that showed both dinosaur characteristics (teeth, bony tail) and bird characteristics (flight feathers).” (p. 763) No hint of controversy over its transitional status is given. **Grade: F.**

*Peppered Moths:* N/A.

*Darwin's Finches:* The textbook calls the finches an example of adaptive radiation. (p. 551) The textbook implies that the Galápagos finches played an important role in the formulation of Darwin's theory, stating: “Darwin noticed several types of small brown birds on the islands with beaks of different shapes. He thought that some were wrens, some were warblers, and some were blackbirds. ... the little brown birds that Darwin thought were wrens, warblers, and blackbirds were actually all species of finches! They, too, were found nowhere else, though they resembled a South American finch species ... Darwin was stunned by these discoveries. He began to wonder whether different Galápagos species might have evolved from South American ancestors. He spent years filling notebooks with ideas about species and evolution. ... Once Darwin learned that the birds were all finches, he hypothesized that they had descended from a common ancestor. Darwin noted that several finch species have beaks of very different sizes and shapes. Each species uses its beak like a specialized tool to pick up and handle its food... Darwin proposed that natural selection had shaped the beaks of different bird populations as they became adapted to eat different foods.” (pp. 452-453, 471-472) The textbook does not mention oscillating evolution, stating that “average beak size in this finch population has increased dramatically,” (p. 472) never mentioning that beak sizes return to normal after the drought. **Grade: F.**

*Whales:* The textbook mentions the whale sequence, claiming that “researchers have found many related fossils that show how modern whales evolve from ancestors that walked on land.” (p. 466) It claims that the drawings are “reconstruction[s] based on fossil evidence” (p. 466) and thus makes no mention that interpretations might not be based upon hard data. No mention is made of the timescale. Polemical language is used, saying, “The evidence we do have, however, tells an unmistakable story of evolutionary change.” (p. 467) **Grade: F.**

*Junk-DNA:* N/A.

### Other Notes:

This textbook is highly dogmatic in its treatment of evolution. It quotes coauthor Joseph Levine stating: “Darwin’s theory of evolution by natural selection is often called ‘the most important scientific idea that anyone has ever had.’ Evolutionary theory provides the best scientific explanation for the unity and diversity of life. It unites all living things in a single tree of life and reminds us that humans are a part of nature. As researchers explore evolutionary mysteries, they continue to marvel at Darwin’s genius and his grand vision of the natural world.” (p. 447) This makes it all the more ironic that in the earlier pages of the book, the authors state: “Good scientists are skeptics, which means that they question existing ideas and hypotheses,” and “[s]cientists must remain open-minded, meaning that they are willing to accept different ideas that may not agree with their hypothesis.” Does it sound like they are applying such a scientific approach to evolution? **Overall Grade: F.**

### **15. National Geographic, Alton Biggs, Lucy Daniel, Edward Ortley, Peter Rillero, Dinah Zike, *Life Science* (McGraw Hill, Glencoe, 2005).**

#### Icons Grading Notes:

*The Miller-Urey Experiment:* The textbook contains a diagram explaining the Miller-Urey experiment, even though it does not depict the apparatus itself. The caption claims that “Stanley Miller and Harold Urey sent electric currents through a mixture of gases like those thought to be in Earth’s early atmosphere. When the gases cooled, they condensed to form an ocean-like liquid that contained materials such as amino acids, found in present-day cells.” (p. 20) The text further states, “Although the Miller-Urey experiment showed that chemicals found in living things could be produced, it did not prove that life began that way.” (p. 21) There is no qualification of any of these statements and the reader is left with the impression that the experiments produced amino acids in earthlike conditions. **Grade: F.**

*Darwin’s Tree of Life:* The textbook treats common ancestry as fact, without question, even including a diagram purporting to show the history of life from bacteria all the way to humans. (p. 166) There is no mention of the Cambrian explosion. **Grade: F.**

*Homology in Vertebrate Limbs:* The textbook defines homology in terms of common ancestry and common origin stating: “Body parts that are similar in origin and structure are called homologous.” (p. 168) It then portrays homology as evidence for common ancestry: “Homologous structures also can be similar in function. They often indicate that two or more species share common ancestors.” (p. 168) There is no mention of data that does not fit with claims of homology. **Grade: F.**

*Haeckel’s Embryos:* The textbook shows drawings of embryos that, while not Haeckel’s original drawings, are re-drawings that nonetheless grossly obscure the differences between early embryos (p. 167). The text states, “Similarities in the embryos of fish, chickens, and rabbits show evidence of evolution.” (p. 167) The text also states that “similarities suggest an evolutionary relationship among all vertebrate species.” (p. 167) There is no mention of dissimilarity. **Grade: F.**

*Archaeopteryx:* The textbook says regarding *Archaeopteryx*, “The 150-million-year-old fossil was an ancestor of birds, and was named *Archaeopteryx*” (p. 397) and “is considered a link

between reptiles and birds.” (p. 435) It thus postures *Archaeopteryx* as an ancestor of birds, but makes no mention of controversy regarding its ancestral status, or controversy over the general hypothesis that birds evolved from reptiles. It states, “Some scientists hypothesize that birds developed from reptiles millions of years ago.” (p. 435) **Grade: F.**

*Peppered Moths:* N/A

*Darwin's Finches:* The textbook states that “Darwin observed that the beak shape of each species of Galápagos finch is related to its eating habits,” (p. 156) and “Darwin observed 13 species of finches on the Galápagos Islands. He noticed that all 13 species were similar, except for differences in body size, beak shape, and eating habits … He also noticed that all the Galápagos finch species were similar to one finch species he had seen on the South American coast. Darwin reasoned that the Galápagos finches must have had to compete for food. Finches with beak shapes that allowed them to eat available food survived longer and produced more offspring than finches without those beak shapes. After many generations, these groups of finches became separate species.” It does not mention that the finches were in fact not that important for the formulation of Darwin’s theory. There is no mention of the study where beak sizes changed in response to a drought, so the best grade it could receive is a D. **Grade: D.**

*Whales:* N/A.

*Junk-DNA:* N/A.

Other Notes:

This textbook is aimed at a younger audience than many of the other textbooks evaluated here, but it too promotes faux-inquiry. After overstating the similarities among vertebrate embryos, it asserts: “Similarities in embryos of fish, chickens, and rabbits show evidence of evolution. Evaluate these embryos as evidence for evolution.” (p. 167) If the textbook only tells students that the evidence supports evolution, what will their conclusion be when they “evaluate” the evidence? Another question instructs students to “Think Critically” and “Compare and contrast the five types of evidence that support the theory of evolution.” Students are supposed to “Think Critically”—but not about whether the evidence supports evolution. That is taken as a given.

**Overall Grade: F.**

**16. Michael J. Padilla, Ioannis Miaoulis, Martha Cyr, *Science Explorer: Life Science* (Prentice Hall, 2009).**

Icons Grading Notes:

*The Miller-Urey Experiment:* N/A

*Darwin's Tree of Life:* The view that all organisms are related is not questioned. It states: “Scientists have combined the evidence from DNA, protein structure, fossils, early development, and body structure to determine evolutionary relationships among species.” (p. 185) Although it does mention the Cambrian period in a diagram of the geological timescale, (p. 194) there is no specific mention of the Cambrian explosion or any suggestion of an explosive origin of animal phyla. **Grade: F.**

***Homology in Vertebrate Limbs:*** The textbook defines homology in terms of common ancestry, stating: “Similar structures that related species have inherited from a common ancestor are known as homologous structures.” (p. 184) However, in the same paragraph it states that this provides evidence for common ancestry: “These similarities provide evidence that these three organisms all evolved from a common ancestor.” (p. 184) There is no mention of any evidence that does not fit with claims of homology. **Grade: F.**

***Haeckel’s Embryos:*** The textbook uses photographs rather than drawings of actual embryos, photographs which selectively depict stages where the embryos are similar. The caption reads, “These animals look similar during their early development,” and the text states, “These similarities suggest that these vertebrate species are related and share a common ancestor.” (p. 183) There is no mention that they are more dissimilar at earlier stages. **Grade: D.**

***Archaeopteryx:*** The textbook states, “Paleontologists think that *Archaeopteryx* and modern birds descended from some kind of a reptile, possibly a dinosaur.” (p. 406) There is no mention of controversy over its ancestral status or controversy over the hypothesis that birds evolved from dinosaurs. **Grade: F.**

***Peppered Moths:*** N/A.

***Darwin’s Finches:*** The textbook states that “Darwin made these drawings of four species of Galápagos finches. The structure of each bird’s beak is an adaptation related to the type of food the bird eats.” (p. 175) It further states that “Darwin found many similarities between Galápagos organisms and those in South America … From his observations, Darwin hypothesized that a small number of different plant and animal species had come to the Galápagos Islands from the mainland. They might have been blown out to sea during a storm or set adrift on a fallen log. Once the plants and animals reached the islands, they reproduced. Eventually, their offspring became different from their mainland relatives. … Like the tortoises, the finches on the Galápagos were noticeably different from one island to the next. The most obvious differences were the varied sizes and shapes of birds’ beaks … An examination of the different finches showed that each species was well-suited to the life it led. Finches that ate insects had narrow, needle-like beaks. Finches that ate seeds had strong, wide beaks.” (pp. 174-175) It does not mention that the finches did not play a major role in the formulation of Darwin’s theory. It also does not mention the study where finch beaks changed in response to a drought. The highest grade it can receive is a D. **Grade: D.**

***Whales:*** The textbook states that “scientists have recently found fossils of ancient whalelike creatures. The fossils show that ancestor of today’s whales had legs and walked on land. This evidence supports other evidence that whales and humans share a common ancestor.” (p. 184) There is no mention of the short timescale or that interpretations of the fossil might be forced by evolutionary thinking. It does not show the misleading pictures, however, so it will receive a D. **Grade: D.**

***Junk-DNA:*** N/A.

***Other Notes:***

This textbook also contains a classic faux-critical thinking exercise, stating, “Identifying Supporting Evidence. Evidence consists of facts that can be confirmed by testing or observation.

As you read, identify the evidence that supports the theory of evolution.” (p. 182) It of course does not ask students to consider any evidence that would not support evolution—only supporting evidence is presented. **Overall Grade: F.**

**17. John H. Postlethwait and Janet L. Hopson, *Modern Biology* (Holt, Rinehart and Winston, 2009).**

Icons Grading Notes:

*The Miller-Urey Experiment:* The textbook contains a drawing of the Miller-Urey apparatus (p. 285), but notes a “new hypothes[is] about the early Earth’s atmosphere … holds that the atmosphere of the early Earth was composed largely of carbon dioxide, CO<sub>2</sub>; nitrogen, N<sub>2</sub>; and water vapor, H<sub>2</sub>O. Laboratory simulations of these atmospheric conditions have shown that both carbon dioxide and oxygen gas interfere with the production of organic compounds.” (p. 285) However, it still leaves students with the impression that these experiments were successful, stating, “Scientists are convinced that basic organic compounds could have formed on the early Earth in many ways.” (p. 285) In fact, in one place it states that “[t]he apparatus shown below is an example of the Miller-Urey experiment modeling conditions on early Earth.” (p. 292) **Grade: D.**

*Darwin’s Tree of Life:* The textbook does not question universal common ancestry, stating that the “‘tree of life’ is a model of the relationships by ancestry among all major groups of organisms.” (p. 10) While it notes that the precise relationships may in some cases be “debated” or “uncertain,” (p. 1078) it nonetheless treats universal common ancestry as a fact, stating, “The data are consistent with the hypothesis that all living organisms inherited their rRNA genes from an ancient organism or form of life. Scientists refer to this unknown ancestor as the *last universal common ancestor*.” (p. 347) There is no mention of the Cambrian explosion. **Grade: F.**

*Homology in Vertebrate Limbs:* The text defines homology in terms of common ancestry, stating: “Biologists define homologous structures as anatomical structures that occur in different species and that originated by heredity from a structure in the most recent common ancestor of the species,” (p.305) and “[h]omologous structures are anatomical structures that share a common ancestry.” (p. 800) However, it uses this as evidence for common ancestry, stating: “One explanation for the commonalities among the forelimb bones of the four animals is that an early ancestor shared by all these vertebrates had a forelimb with a similar bone structure.” (p. 305) No mention of any data that does not fit with claimed homology is given. **Grade: F.**

*Haeckel’s Embryos:* The textbook uses actual embryo photos which selectively show stages of development said to be “remarkably similar” and “very alike.” (p. 306) It then states: “One possible explanation for these similarities is that vertebrates share a common ancestor and have inherited stages of development.” (p. 306) **Grade: D.**

*Archaeopteryx:* The textbook postures *Archaeopteryx* as a transitional link, stating it has “characteristics of both birds and dinosaurs.” (p. 843) A phylogenetic diagram implies it is not the ancestor of modern birds, but this is not made explicit in the text, as it states that *Archaeopteryx* fossils are “[t]he oldest known bird fossils.” (p. 842) There is no hint of any controversy over its status. Due to the diagram, it will receive a D-. **Grade: D-.**

*Peppered Moths:* N/A.

*Darwin's Finches:* The Galápagos finches are portrayed as a good example of evolution, and the textbook implies that the Galápagos finches played a role in Darwin's formulation of his theory, stating: "Darwin saw the animals of the Galápagos Islands as evidence of descent with modification. For example, the islands are home to 13 similar species of finches. Each of these bird species has a beak that is best adapted for a certain kind of food. But Darwin suspected that all 13 species descended and diverged from just a few ancestral finches." (p. 299) There is mention of beak evolution (p. 402) but no mention of the fact that beak sizes oscillate in response to cyclical climate changes. **Grade: F.**

*Whales:* The hypothesis that whales evolved from land mammals is treated as fact, as the textbook states, "The hypothesis of whale evolution from land mammals is strongly supported by these fossil finds." (p. 304) There is no mention that our understanding of these "transitional forms" or the reconstructed fossil poses might be the result of evolutionary interpretation and not hard data. Dates are given showing that *Pakicetus* lived at 50 mya whereas *Dorudon* lived at 40 mya, and there is also a vague timeline. (pp. 304, 307) No direct mention of the timescale is given, and the reader must infer it. There are no mentions of any challenge to the hypothesis of unguided evolution from a short timescale. Thus, it receives a D-. **Grade: D-.**

*Junk-DNA:* The textbook states that 98% of our DNA is noncoding (p. 255) but gives no hint that it may have function, apart from a statement regarding introns that an intron "performs important functions even though it is not translated." (p. 220) None of this is cited as evidence for evolution. **Grade: D+.**

Other Notes:

This textbook asks students, "What evidence supports the hypothesis that whales evolved from land-dwelling mammals?" (p. 307)—another example of a faux-critical thinking question.

**Overall Grade: F.**

**18. Peter H. Raven, George B. Johnson, Kenneth A. Mason, Jonathan B. Losos, and Susan R. Singer, *Biology*, (9<sup>th</sup> ed., McGraw Hill, 2011).**

Icons Grading Notes:

*The Miller-Urey Experiment:* Contains Miller-Urey apparatus picture. Both text and caption mislead students to think the atmosphere contained methane and ammonia. The text says that "they attempted to reproduce the conditions in the Earth's primitive oceans under a reducing atmosphere," (p. 509) and "[t]hus, the key molecules of life could have formed in the reducing atmosphere of the early Earth." (p. 510) The picture states that the atmosphere included NH<sub>3</sub> (ammonia) and CH<sub>4</sub> (methane) and that it "contained a mixture of gases thought to resemble the primitive Earth's atmosphere." (p. 510) The reason why this gets a D- and not an F is because there is a slight qualification which says: "the jury is still out" on whether their hypothesis is correct. (p. 509) **Grade: D-.**

*Darwin's Tree of Life:* The textbook treats common descent as an uncritical fact, stating, "The process of descent with modification from common ancestry results in all species being related in this branching, hierarchical fashion, and their evolutionary history can be depicted using branching diagrams or phylogenetic trees," (p. 457) and "[d]ifferent life forms descended from

the same origin event.” (p. 507) The text does mention that individual trees for specific groups are “hypotheses,” although it suggests that we must pick between “the best hypothesis of evolutionary relationship,” implying that evolutionary relationships of some form are always present. The overall claim of universal common ancestry is clearly treated as an absolute fact. It mentions the Cambrian explosion in the body of the text (pp. 645-646), but it does not mention how it challenges neo-Darwinism. **Grade: D.**

*Homology in Vertebrate Limbs:* The textbook defines homology as similarity due to inheritance from a common ancestor, but then in a circular fashion it uses homology as evidence for common ancestry. The textbook thus defines homology as “structures with different appearances and functions that all derived from the same body part in a common ancestor,” (p. 428) but then says, “Why should these very important structures be composed of the same bones ... when we consider that all of these animals are descended from a common ancestor, it is easy to understand that natural selection has modified the same initial starting blocks to serve very different purposes.” (p. 428) There is no mention of evidence that does not fit with claims regarding homology. **Grade: F.**

*Haeckel’s Embryos:* The textbook has one single drawing of what it calls a “generalized embryo,” (p.694) which is apparently meant to represent the embryos of all vertebrates. This is extremely misleading and perhaps worse than using Haeckel’s drawings, as it does not even give any hint that there are differences between the embryos of various chordates. It calls pharyngeal pouches “pharyngeal slits” and says, “The presence of these structures in all vertebrate embryos provides evidence of their aquatic ancestry.” (p. 694) **Grade: F.**

*Archaeopteryx:* The textbook presents *Archaeopteryx* as the transitional link between dinosaurs and modern birds, stating, “The specimen is clearly intermediate between birds and dinosaurs.” (p. 425) It does not point out that modern birds are probably not descended from it and it does not hint that there is controversy over its ancestry or transitional status. **Grade: F.**

*Peppered Moths:* The textbook uses staged photos, stating the moths were “placed on trees.” (p. 420) It does not mention that this misrepresents the natural situation. However, the accompanying text does at least hint that there were “deficiencies” in Kettlewell’s original studies. (p. 420) Unfortunately, in the end it asserts that Kettlewell’s original studies were true. **Grade: D.**

*Darwin’s Finches:* The textbook describes the Galápagos finches as a good example of evolution by natural selection, stating that “the year-to-year changes in average beak depth represent evolutionary change resulting from natural selection.” (p. 419) The textbook does acknowledge that selection on the finch beaks oscillates between wet and dry years, stating that “when normal rains returned, average beak depth of the population decreased to its original size,” and “[i]n dry years, when only large, tough seeds are available, the mean beak depth increases. In wet years, when many small seeds are available, mean beak depth decreases.” (p. 419) However, it implies that the finches played an important role in the development of Darwin’s ideas, stating, “The correspondence between beaks of the finch species and their food source suggested to Darwin that natural selection had shaped them.” (p. 418) **Grade: D.**

*Whales:* The textbook mentions the whale sequence but only vaguely alludes to the limited amount of time available in the fossil record, not stating the actual < 10 million years available. “All three fossil forms occurred in the Eocene period, 45-55 MYA.” (p. 425) It does not note

that fossil reconstructions may be based upon evolutionary interpretation and not hard data, and it uses the term “Whale ‘missing links.’” (p. 425) **Grade: D-**

*Junk-DNA:* The textbook acknowledges that recent discoveries have led many scientists to suspect that much noncoding DNA is not junk, stating, “At first glance it appeared that all this extra DNA was ‘junk’ DNA, DNA just along for the ride. But it is beginning to look like this ncDNA may have more of a function than was previously assumed.” (p. 485) However, it does not note that junk-DNA paradigm was the result of evolutionary thinking, instead implying that Darwinian selection caused them to suspect function for non-coding DNA. As a result, it gets not a C but a C-. **Grade: C-**

*Other Notes:*

Again, this textbook encourages faux-critical thinking, encouraging students to “List evidence that supports the theory of evolution.” (p. 8) It presents evolution in highly dogmatic terms, stating that “information from many different areas of biology—fields as different as anatomy, molecular biology, and biogeography—is only interpretable scientifically as being the outcome of evolution.” (p. 417) It also cites as evidence for evolution the claim that “[s]ome structures are imperfectly suited to their use.” (p. 429) It thus attacks ID by claiming that “imperfect design” is best explained by natural selection: “natural selection is like a tinkerer, working with whatever material is available to craft a workable solution, rather than like an engineer, who can design and build the best possible structure for a given task. Workable, but imperfect, structures such as the vertebrate eye are an expected outcome of evolution by natural selection.” (pp. 429-430) It later purports to refute the “intelligent design argument” stating: “inefficiencies of certain designs, such as the vertebrate eye and the existence of vestigial structures, do not support the idea of an intelligent designer.” (pp. 432-433) Finally, this textbook makes the outlandish and wholly speculative statement in favor of human evolution: “The difference of only two amino acids between humans and other primate FOXP2 appears to have made it possible for language to arise.” (p. 485) Could two amino acid changes have created language in humans? Apparently this textbook expects students to believe that it did. **Overall Grade: D-**

**19. Jane B. Reece, Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, Robert B. Jackson, *Campbell Biology* (9<sup>th</sup> ed., Benjamin Cummings, 2011).**

*Icons Grading Notes:*

*The Miller-Urey Experiment:* The textbook contains a picture of the Miller-Urey apparatus with a caption that implies the experiment mimicked conditions on the early earth: “Miller set up a closed system to mimic conditions thought to have existed on the early Earth.” (p. 59) It further states, “Miller concluded that complex organic molecules could arise spontaneously under conditions thought to have existed on the early Earth,” (p. 59) and, in a much later chapter, it states that Miller used “laboratory conditions comparable to those that scientists at the time thought existed on the early Earth.” (p. 508) There is a slight qualification in this later chapter: “it is unclear whether the atmosphere of the early Earth contained enough methane and ammonia to be reducing. Some evidence suggests that the early atmosphere was made up primarily of nitrogen and carbon dioxide and was neither reducing nor oxidizing (electron-removing).” (p. 508) However, the textbook wrongly claims that “such ‘neutral’ atmospheres have also produced organic molecules.” (p. 508) The textbook confidently states, wrongly, that “Miller-

Urey-type experiments demonstrate that the abiotic synthesis of organic molecules is possible under various assumptions about the composition of the early atmosphere.” (p. 508) **Grade: D.**

*Darwin’s Tree of Life:* In a chapter titled “Phylogeny and the Tree of Life,” this textbook states that there is a “common ancestor of all life.” (p. 552) Earlier it states, “All of life is connected through its long evolutionary history.” (p. 16) It further notes that Darwin “attributed the unity of life to the descent of all organisms from an ancestor that lived in the remote past” and “viewed the history of life as a tree, with multiple branches from a common trunk.” (p. 457) Although the textbook notes that individual hypotheses about ancestry are testable, it treats the overall concept of universal common ancestry and a “tree of life” as unquestioned fact. It does mention the Cambrian explosion (pp. 518, 657) but does not treat it as a problem for neo-Darwinian evolution. **Grade: D.**

*Homology in Vertebrate Limbs:* The textbook defines homology as similarity resulting from common ancestry, stating: “Similarity resulting from common ancestry is known as homology.” It then cites homology as evidence for common ancestry, stating that homologous features “make little sense except in the context of evolution” and “represent variations on a structural theme that was present in their common ancestor.” (p. 463) It further uses “molecular homologies” to argue for common ancestry, stating that similarities in the genetic code of living organisms make it “likely that all species were descended from common ancestors that used this code.” (p. 463) **Grade: F.**

*Haeckel’s Embryos:* The textbook uses photos of actual vertebrate embryos (a chicken and a human) but chooses a stage that best fits with the predictions of Darwinian evolution (p. 463). There is no mention of dissimilarity between the embryos in earlier stages, and the similarities are said to provide evidence for common ancestry: “Descent with modification can explain such similarities.” (p. 463) The term “gill slit” is not used. **Grade: D.**

*Archaeopteryx:* The textbook presents *Archaeopteryx* as a link between theropod dinosaurs and birds, never mentioning any controversy regarding the transitional status of *Archaeopteryx*. (p. 719) **Grade: F.**

*Peppered Moths:* N/A.

*Darwin’s Finches:* The textbook describes the Galápagos finches as “a famous example of adaptive radiation.” (p. 16) It notes that researchers since Darwin made further discoveries about the finches (pp. 17, 23, 456) but implies that the finches played a role in the development of Darwin’s theory: “Darwin collected specimens of these birds during his 1835 visit to the remote Galápagos Islands,” (p. 16) and “Darwin’s interest in the geographic distribution of species was further stimulated by the Beagle’s stop at the Galápagos, a group of volcanic islands near the equator about 900 km west of South America. Darwin was fascinated by the unusual organisms there. The birds he collected included the finches mentioned in Chapter 1 and several kinds of mockingbirds … Darwin hypothesized that the Galápagos had been colonized by organisms that had strayed from South America and then diversified, giving rise to new species on the various islands. … The finches’ various beaks and behaviors are adapted to the specific foods available on their home islands. Darwin realized that explaining such adaptations was essential to understanding evolution.” (p. 456) The textbook also notes that during a drought, “[b]irds with larger, deeper beaks were able to were better able to crack and eat these larger seeds, and they survived at a higher rate than finches with smaller beaks,” (p. 469) and that “finches with larger,

deeper beaks were better able to survive during a drought because they could eat the large, hard seeds that were available.” (p. 1163) But there is no mention of oscillating selection, of how beak sizes in the population reverted back to original size after the drought ended. **Grade: F.**

*Whales:* The textbook mentions the whale sequence, stating, “Multiple lines of evidence support the hypothesis that cetaceans evolved from terrestrial mammals,” (p. 466) but it makes no mention of any potential barriers to whale evolution from the timeline. It does have a graphic which shows a timescale, but it does not make it clear that whales evolved in less than 10 million years. Since there are dates on the timeline, it receives a D- rather than an F. There is no mention that fossil reconstructions may be based upon evolutionary interpretation and not hard data. **Grade: D-.**

*Junk-DNA:* The textbook states that “noncoding DNA was often described in the past as ‘junk DNA.’ However, much evidence is accumulating that this DNA plays important roles in the cell.” (p. 434) However, it does claim that some noncoding DNA provides evidence for evolutionary history, specifically citing “pseudogenes” as an example. (p. 438) The textbook implies that they are non-functional and result from evolutionary processes: “pseudogenes, former genes that have accumulated mutations over a long time and no longer produce functional proteins.” (p. 434) **Grade: D+.**

#### Other Notes:

This textbook is typically dogmatic, stating: “Evolution is supported by an overwhelming amount of scientific evidence.” (p. 460) It also calls evolution “the Overarching Theme of Biology” and quotes Dobzhansky’s famous dictum, “Nothing in biology makes sense except in the light of evolution.” (p. 11) It too encourages faux-critical thinking, stating: “Summarize the different lines of evidence supporting the hypothesis that cetaceans descended from land mammals and are closely related to even-toed ungulates” (p. 458)—not giving students any opportunities or encouragements to also consider contrary evidence. **Overall Grade: F.**

## **20. David Savada, H. Craig Heller, Gordon H. Orians, William K. Purves, David M. Hillis, Life: The Science of Biology (Sinauer Associates, 8<sup>th</sup> ed., 2008).**

#### Icons Grading Notes:

*The Miller-Urey Experiment:* Contains Miller-Urey apparatus picture. Both text and caption mislead students to think the atmosphere contained methane and ammonia. The text states, “Stanley Miller and Harold Urey set up an experimental ‘atmosphere’ containing the gases they believed to have been present in Earth’s early atmosphere: hydrogen gas, ammonia, methane gas, and water vapor.” (p. 61) It later states, “The Miller-Urey experiment simulated possible atmospheric conditions on primitive Earth.” (p. 62) The caption states the experiment used “conditions similar to those that existed on primitive Earth” and concludes, “The chemical building blocks of life could have been generated in the probable atmosphere of early Earth.” (p. 62) **Grade: F.**

*Darwin’s Tree of Life:* The textbook treats common descent as an uncritical fact, stating, “One of the greatest unifying concepts in biology is that all of life is connected through its evolutionary history. The complete, nearly 4-billion-year evolutionary history of life is known as the ‘Tree of Life.’” (p. 544) It also states, “All living organisms share a common ancestor and are related

through the phylogenetic Tree of Life.” (p. 545) It mentions the Cambrian explosion in the body of the text, (pp. 472-473) but it does not mention how it challenges neo-Darwinism. **Grade: D.**

*Homology in Vertebrate Limbs:* The textbook defines homology as resulting from common ancestry, stating: “Any features shared by two or more species that may have been inherited from a common ancestor are said to be homologous.” (p. 544) However, there is circularity in that it says that similar structures were used to infer common ancestry: “Biologists then inferred the evolutionary relationships among living and fossil organism by comparing their anatomical similarities and differences.” (p. 10) **Grade: F.**

*Haeckel’s Embryos:* This textbook does not contain a diagram comparing vertebrate embryos in the pharyngular stage, nor, as far as I can tell, does it use embryology to argue for common ancestry. However, it does have an excellent diagram in the chapter on animal development which shows differences in the earliest stages of vertebrate development, noting that frogs have complete cleavage, chickens have incomplete cleavage, and mammals have rotational cleavage. (p. 924) It does not mention any problems that embryology poses for common ancestry. As a result, it will receive a B. **Grade: B.**

*Archaeopteryx:* The textbook says that *Archaeopteryx* is a fossil that “demonstrate[s] the evolution of birds from dinosaurs.” (p. 733) There is no mention of controversy over its ancestral status or controversy over the hypothesis that birds evolved from dinosaurs. **Grade: F.**

*Peppered Moths:* N/A.

*Darwin’s Finches:* The textbook uses the Galápagos finches as a good example of “allopatric speciation” (p. 511) and says that “Darwin’s finches (as they are usually called, because Darwin was the first scientist to study them) arose in the Galápagos from a single South American species that colonized the islands.” (p. 511) To a certain extent, it thus implies they played a major role in the formulation of Darwin’s theory but never mentions that they did not. It does not mention studies regarding how finch beak sizes change in response to drought or rain. **Grade: D+.**

*Whales:* N/A. This textbook has no pictures of whale fossils and only briefly alludes to whale evolution, stating: “The completely aquatic marine cetaceans—whales and dolphins—evolved from artiodactyl ancestors.” (p. 737) While this textbook treats whale origins in a biased and inaccurate manner, there is not enough material to grade it.

*Junk-DNA:* The textbook states: “Why do the cells of most organisms have so much noncoding DNA? Does this noncoding DNA have a function, or is it ‘junk’? Although much of this DNA does not appear to have a direct function, it can alter the expression of the surrounding genes. The degree or timing of gene expression can be changed dramatically depending on the gene’s position relative to noncoding sequences. Other regions of noncoding DNA consist of pseudogenes that are simply carried in the genome because the cost of doing so is very small. These pseudogenes may become the raw material for the evolution of new genes with novel functions. Still other noncoding sequences consist of parasitic transposable elements that spread through populations because they reproduce faster than the host genome.” (p. 534) The text also compares the amount of DNA in lungfish, some salamanders, and lilies to humans and argues that most of the DNA is nonfunctional. (p. 533) Generally speaking, it considers much of this to be “functionless DNA.” (p. 534) **Grade: D.**

Other Notes:

This textbook is entirely pro-Darwinian evolution, but it takes a slightly less dogmatic tone than some. Nonetheless it states that “a rich array of geological, morphological, and molecular data support and enhance the factual basis of evolution.” (p. 487) **Overall Grade: D.**

**21. Eric J. Simon, Jane B. Reece, Jean L. Dickey, *Campbell Essential Biology* (Benjamin Cummings, 4<sup>th</sup> ed., 2010).**

Icons Grading Notes:

*The Miller-Urey Experiment:* The textbook contains a picture of the Miller-Urey apparatus, and claims the experiments asked, “Could biological molecules arise spontaneously under conditions like those on early earth? Miller and Urey began with the hypothesis that a closed system designed to simulate such conditions in the laboratory could produce biologically important organic molecules from inorganic ingredients.” (p. 297) The caption reads, “The abiotic production of organic molecules: A laboratory simulation of early-Earth chemistry.” (p. 297) It does note that “Miller’s ‘early atmosphere’ was almost certainly incorrect in some ways.” (p. 297) However, it then says: “Laboratory analogs of the primeval Earth have produced all 20 amino acids and several sugars. These laboratory results support the concept of the abiotic synthesis of organic molecules on the early Earth.” (p. 297) **Grade: D.**

*Darwin’s Tree of Life:* The textbook treats common ancestry as a fact: “All life is connected. And the basis for this kinship is evolution,” (p. 10) and “Darwin’s boldest hypothesis was that all forms of life are related.” (p. 251) Later it states, “In Darwin’s view, the history of life is analogous to a tree. Patterns of descent branch off from a common trunk, the first organism, to the tips of millions of twigs representing the species living today. At each fork of the evolutionary tree is an ancestor common to all evolutionary branches extending from that fork. Closely related species share many traits because their lineage of common descent traces to a recent fork of the tree of life. Biologists represent these patterns of descent with an evolutionary tree...” (p. 255) It mentions the Cambrian explosion (pp. 295, 339) but does not frame it as a problem for Darwinian evolution. **Grade: D.**

*Homology in Vertebrate Limbs:* The textbook defines homology as resulting from common ancestry: “Such similarity in structure due to common ancestry is called homology.” (p. 250) In a circular fashion, it then uses homology as evidence for common ancestry, stating, “Homologous structures: anatomical signs of descent with modification.” (p. 250) **Grade: F.**

*Haeckel’s Embryos:* The textbook uses actual photographs of embryos (p. 251) and claims the embryos are highly similar, stating: “At this stage, the embryos of fishes, frogs, snakes, birds, and apes—indeed, all vertebrates—look more alike than different.” (p. 251) It does not mention that vertebrate embryos are more dissimilar at earlier stages. **Grade: D.**

*Archaeopteryx:* The textbook states regarding *Archaeopteryx*, “Despite its feathers, *Archaeopteryx* is not considered an ancestor of today’s birds. Instead, it probably represents an extinct side branch of the bird lineage.” (p. 278) It thus notes that birds are probably not descended from *Archaeopteryx*, but it does not mention any general controversy over the claim that birds are descended from dinosaurs. **Grade: C.**

### *Peppered Moths:* N/A

*Darwin's Finches:* The textbook calls the finches an example “of natural selection in action.” (p. 12) It states: “Over a span of two decades, researchers measured changes in beak size in a population of a species of ground finches that eats mostly small seeds. In dry years, when all seeds are in short supply, the birds must eat more large seeds. Birds with larger, stronger beaks have a feeding advantage and greater reproductive success, and the average beak depth for the population increases. During wet years, smaller beaks are more efficient for eating the now abundant small seeds, and the average beak depth decreases.” (pp. 12-13) It does not claim that the finches were important to the development of Darwin’s theory and explains that the finch beak size oscillates. **Grade: C.**

*Whales:* The textbook only shows one diagram of purported whale transitional fossil, but the text states that there is “a series of transitional whale fossils connecting these aquatic mammals to four legged-mammals.” (p. 248) There is no mention of the short timeline of this purported series, nor is there any mention of bias in the interpretations of these fossils. **Grade: F.**

*Junk-DNA:* The textbook notes, “Most complex eukaryotes have a huge amount of noncoding DNA—about 98% of human DNA is of this type.” (p. 230) It does note, however, that “[s]ome of this noncoding DNA is made up of gene control sequences such as promoters, enhancers, and microRNAs … [o]ther noncoding regions include introns (whose total length in a gene may be ten times greater than the total length of the exons) and repetitive DNA (some of which is used in DNA profiling). Some noncoding DNA is important to our health, with certain regions known to carry several disease-causing mutations. But the function (if any) of most noncoding DNA remains unknown.” (pp. 230-231) Elsewhere, it suggests that introns may be “unintelligible sequences of letters.” (p. 182) **Grade: D.**

### Other Notes:

This textbook has a typically dogmatic opening, stating that evolution is “the theme that unifies all of biology” (p. 3) and “the core theme of biology.” (p. 18) It soon thereafter states that Darwin’s conclusion is “inescapable”: “As evolutionary biologist Stephen Jay Gould put it, Darwin based his mechanism of natural selection on ‘two undeniable facts and an inescapable conclusion.’” (p. 11) This textbook claims that “selected DNA sequences of chimps and humans are better than a 98% match,” (p. 251) ignoring evidence to the contrary that human and chimp DNA has larger differences.<sup>xvi</sup> It also dramatically overstates Craig Venter’s research, claiming that he “synthesized from scratch the entire genome of *Mycoplasma genitalium*.” (p. 293) Venter didn’t synthesize it from scratch, as his team simply copied all the genetic code from a pre-existing bacterium. The textbook claims that this may “help answer fundamental questions about the origins of life in nature,” but ironically, Venter’s research shows that intelligence is needed to create life. **Overall Grade: D.**

### **22. Cecie Starr, Ralph Taggart, Christine Evers, Lisa Starr, *Biology: The Unity and Diversity of Life* (12<sup>th</sup> ed. 2009).**

### Icons Grading Notes:

*The Miller-Urey Experiment:* The textbook contains a diagram of the Miller-Urey apparatus with a caption implying the experiment simulated conditions on the early earth: “Miller circulated water vapor, hydrogen gas ( $H_2$ ), methane ( $CH_4$ ), as well as ammonia ( $NH_3$ ) in a glass chamber to simulate the first atmosphere.” (p. 319) The text does note that there have since been questions about the composition of the earth’s early atmosphere, stating: “Since Miller’s experiment, researchers have revised their ideas about which gases were present in Earth’s early atmosphere.” (p. 319) But it leaves students with the impression that the experiment or some variant of it produced amino acids: “We can only say that such a scenario is plausible, given what we know about chemistry.” (p. 319) **Grade: D.**

*Darwin’s Tree of Life:* The textbook at points calls the tree of life “one hypothesis of how all organisms are related by shared evolutionary history” (p. 313) but in other passages it treats the tree of life as a fact. For example, it states: “we continue to refine our understanding of how all species are interconnected by shared ancestry.” (p. 312) The textbook does mention the Cambrian explosion (for example, pp. 270, 323, 406) but does not discuss the problem it poses for Darwinian evolution. Because in at least one instance it calls the tree of life a “hypothesis,” the textbook will receive a D+. **Grade: D+.**

*Homology in Vertebrate Limbs:* The textbook defines homology in terms of common ancestry, stating: “Similar body parts that reflect shared ancestry are called homologous structures.” (p. 304) However, it then uses homology as evidence for common ancestry, stating: “similarities in the structure of one or more body parts is often evidence of a common ancestor.” (p. 304) **Grade: F.**

*Haeckel’s Embryos:* The textbook uses actual photos rather than drawings of embryos, but selectively chooses photos which fit the theory (p. 306). It fails to mention that earliest stages of development are dissimilar. Rather, it states “Similar patterns of embryonic development may be evidence of evolutionary relationships” and “embryos are similar in the early stages of development.” (p. 306) **Grade: D.**

*Archaeopteryx:* The textbook presents *Archaeopteryx* as a transitional link between reptiles and birds, calling it a “link” which has “traits intermediate between two groups.” (p. 432) It says nothing about the fact that modern birds are probably not descended from *Archaeopteryx*, nor does it give any hint that there is a controversy over its ancestry or the transitional status of *Archaeopteryx*. **Grade: F.**

*Peppered Moths:* The textbook uses staged photos claiming they depict moths “on a nonsooty tree trunk” (p. 283) without making any mention that they misrepresent the natural situation. It describes Kettlewell’s experiments as a demonstration of natural selection without mentioning any flaws in the classical theory. **Grade: F.**

*Darwin’s Finches:* The textbook frames the Galápagos finches as an example of natural selection where “over many generations, a population’s environment may influence traits shared by its individuals” (p. 265) and “Different kinds of finches populate the coasts, dry lowlands, and mountain forests of the islands. (p. 264) While not specifically mentioning the finches by name, in the section discussing the finches it explains the standard finch story: “suppose a group of seed-eating birds lives in a dry environment where soft seeds are scarce. A bird is born with an extra-strong bill that allows it to crack open hard seeds that other members of the population cannot. Thus, the strong-billed bird can access an extra food source. All other things being

equal, the strong-billed bird has a better chance of surviving and reproducing ... After many generations, strong-billed birds would probably predominate in this population.” (pp. 264-265) While it doesn’t refer specifically to the finches, this is the precise standard story commonly told regarding finches in textbooks. The story fails to mention that there was oscillation of wet and dry years which also caused beak sizes to decrease. Moreover, it wrongly implies that the finches played an important role in the formulation of Darwin’s theory. (p. 264) **Grade: F.**

*Whales:* The textbook mentions the whale sequence calling the fossils “missing links,” with diagrams of the fossils. (p. 269) While it gives dates for a couple fossils, it never provides enough information to explain the short geological timespan allowed for this transition, nor does it note any challenges to neo-Darwinian evolution as a result of the many changes which must happen in this short timespan. It also mentions nothing about evolutionary interpretation and bias governing the reconstruction of these fossils. **Grade: F.**

*Junk-DNA:* N/A

Other Notes:

This textbook claims that “The change of two amino acids [in FOXP2] may have contributed to the development of language in humans.” (p. 256) It promotes myths about evolution such as the claim that humans “use our legs, but not our coccyx bones.” (p. 261) The text also promotes materialist views of the origin of life as well as the fallacy that extraterrestrial life somehow necessarily would support an unguided chemical origin of life: “Suppose scientists do find evidence of past or present microbial life on another planet. Would it matter? Such a discovery would support the hypothesis that life can arise spontaneously as a consequence of chemical reactions.” (p. 328) In what initially appears to be a positive statement, the book contains a “Guide to Critical Thinking” which encourages students to ask questions like “Is there another way to interpret the evidence?” or “What other evidence would help me evaluate the alternatives?” (p. 11) Unfortunately, when it comes to Darwinian evolution, the textbook does not practice what it preaches and offers no alternatives and never discusses non-Darwinian ways to interpret the evidence. **Overall Grade: F.**

## VII. Comparison to Jonathan Wells’ 2000 Textbook Evaluation

When Jonathan Wells published *Icons of Evolution* in 2000, I was a graduate student at the University of California at San Diego, conducting research and taking courses at Scripps Institution for Oceanography. In the fall of 2000, Eugenie Scott guest lectured at a Scripps graduate seminar that covered the debate over evolution. “I want you all to see this book,” Dr. Scott told our class as she held up a copy of *Icons*. This book will be a “royal pain in the fanny” for pro-Darwin educators, she warned.

Dr. Scott’s words were prescient. In an appendix to *Icons*, Dr. Wells had published an evaluation of then-current biology textbooks and their treatment of various lines of evidence—the “icons”—commonly used to support Darwinian evolution. Wells evaluated textbook coverage of seven icons: the Miller-Urey experiment, the tree of life, homology in vertebrate limbs, Haeckel’s embryos, *Archaeopteryx*, peppered moths, and Darwin’s finches. His results were striking. Mainstream biology textbooks universally omitted important information and/or printed outright inaccurate claims when promoting neo-Darwinian evolution to students.

Wells' critique of the inaccurate treatment of the icons of evolution in textbooks has now become a standard fixture in the ongoing national debate over evolution education. However, it's important to evaluate the extent to which Wells' critiques have influenced the textbooks themselves, for this bears upon the key question of whether textbooks are presenting evolution accurately in 2011.

One difference between the 2000 and 2011 reviews pertains to Haeckel's embryo drawings, which received higher grades in the current review than in the 2000 review. This is largely because most (though not all) current textbooks use photographs of embryos instead of colorized drawings, whereas in Wells' 2000 review 80% of the textbooks received an F due to their use of misleading drawings. In contrast, only about 22% of the textbooks in this 2011 survey received an F for Haeckel's embryos. In the case of Ken Miller's most recent edition of *Biology*, both drawings and photographs of embryos have been removed. As noted, such improvements are likely due to widespread public awareness of the inaccuracies in embryo drawings which came about after Wells' criticisms in his 2000 review.

Despite this shift, the average grade for Haeckel's embryos in this current textbook evaluation remains a D. Textbooks continue to overstate the similarities between the earliest stages of vertebrate embryos—more of them today just do that using cherry-picked photographs rather than inaccurate drawings.

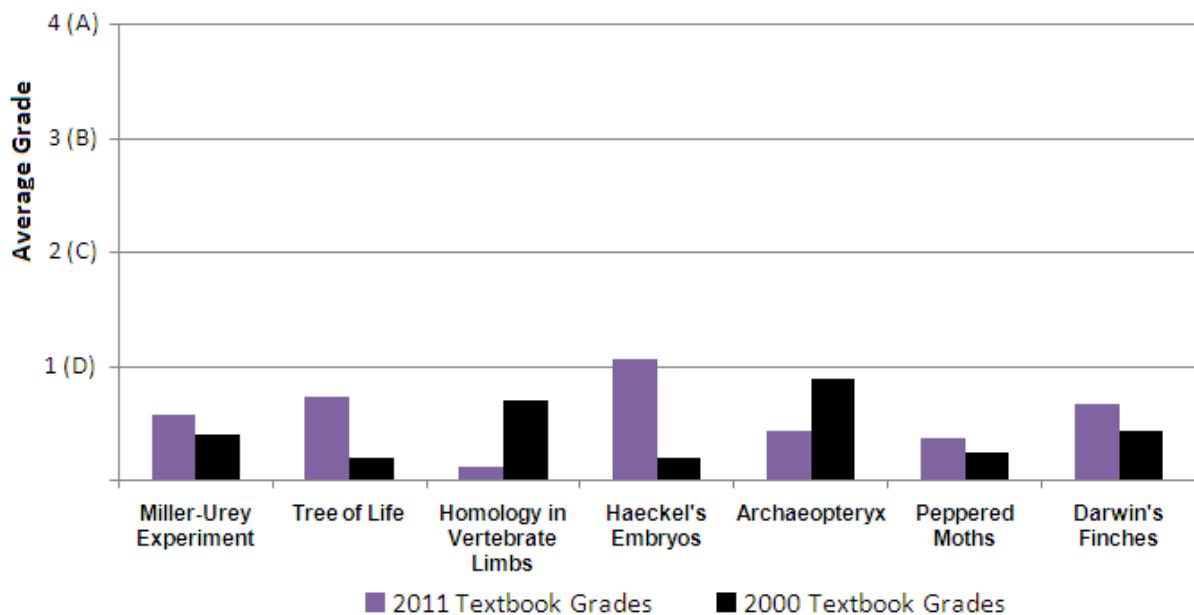
Another icon with slight improvement was Darwin's tree of life, albeit at a near-trivial level. Despite increasing problems faced by scientists seeking to reconstruct a tree of life, the notion that all living organisms are related was universally treated as fact in all textbooks in this review. However, textbooks in the 2011 review were more likely to mention the Cambrian explosion (72%) than in the 2000 review (20%). But even when the Cambrian explosion was mentioned, it was *never* framed as actually posing any challenge to neo-Darwinian evolution.

Not all icons saw improvement. For example, this review saw a significantly higher percentage of F grades for homology in vertebrate limbs. 19 of 22 textbooks reviewed here received an F for this icon, compared only 3 out of 10 in the 2000 review. Similarly, of the 19 textbooks in this review that covered *Archaeopteryx*, 14 received an F. In contrast, only 4 of the textbooks in the 2000 review received an F for *Archaeopteryx*.

Another change is that more textbooks in the 2011 review omit the peppered moth icon, probably another effect of criticisms raised by Wells. While some icons, such as Darwin's finches, homology in vertebrate limbs, or the “tree of life” remain in all the textbooks evaluated, the peppered moth was found in only 10 of the 22 textbooks. This is a marked change from Wells' 2000 textbook review where 80% of the textbooks reviewed contained the peppered moth.

**The average grade for each icon was a D or below, as seen in Figure 4 below, which compares the average grades (on a 4-point GPA scale) for each of the seven icons analyzed in both Wells' 2000 review and this 2011 review.**

*Figure 4: Comparison of Average Grades of Icons in 2000 and 2011 Textbook Reviews.*



As seen in Figure 4, textbooks have not shown much improvement since Wells' 2000 review, and in some cases—homology in vertebrate limbs and *Archaeopteryx*—they performed worse in the 2011 review. Aside from Haeckel's embryos and perhaps the Tree of Life, no icon showed non-trivial levels of improvement. And as noted, even Haeckel's embryos still performed poorly.

Regarding the new icons, whale evolution is becoming an increasingly popular new icon, as it was present in 15 out of 22 textbooks surveyed here. Junk DNA was present in nearly as many textbooks (13 out of 22). Textbooks treated junk-DNA better than was expected, and it was rarely used as an argument for evolution. However, many textbooks fail to explicitly recognize the extensive evidence of function for non-coding DNA.

Most significantly, however, all textbooks reviewed in this 2011 review promote neo-Darwinian evolution in a highly biased, pro-Darwin-only fashion. Some textbooks discussed the fact that there are criticisms of evolution only for the purpose of dismissing them without serious discussion. As discussed in Section VI, a number of textbooks use faux-critical thinking exercises, where students are asked questions but only allowed to answer them in a manner that affirms evolution.

This review shows that current biology textbooks contain essentially no recognition of legitimate scientific controversy over neo-Darwinian evolution and commonly print inaccurate or biased information when promoting evolution to students. There remains enormous room and need for improvement.

## VIII. Conclusion

In *Origin of Species* Darwin challenged future students of science to remember that “a fair result can be obtained only by fully stating and balancing the facts and arguments on both sides of each question.”<sup>xvii</sup> Despite the fact that leading science education theorists agree that students learn science best when taught “to discriminate between evidence that supports … or does not support”<sup>xviii</sup> a given concept, many modern defenders of Darwin’s ideas reject his advice when teaching evolution.

Rather than encouraging students to understand both sides of the evidence, wrestle with it, and form their own opinions, the primary goal of many biology textbooks appears to be to get students to accept neo-Darwinian evolution. As this review shows, biology textbooks only allow students to hear one side of the scientific debate over neo-Darwinian evolution, and then form their opinion.

Science education authorities today warn of two primary deficiencies in science education. First, insufficient numbers of students are being inspired to pursue careers in science.<sup>xix</sup> Second, many Americans simply don't understand science and are not scientifically literate.<sup>xx</sup>

Unfortunately, the one-sided teaching of evolution in biology textbooks doesn't just misinform students about the facts of biology; it also fails to encourage them to develop critical thinking skills and does not inspire them to become scientists. The inaccurate treatment of evolution in biology textbooks thus misses an important opportunity to address some of the biggest problems facing science education today.

By teaching students about the facts and arguments on both sides of the scientific debate over evolution, teachers could help work towards solving problems in science education. Students would learn more about the scientific evidence and improve their scientific critical thinking skills, becoming better scientists.

Unfortunately, as this review has made clear, biology textbooks have a long way to go before they meet Darwin's standards of fairness. It seems that those who desire accuracy and objectivity in evolution-education will have to continue to be a "royal pain in the fanny" of textbook publishers.

**For more information about teaching evolution objectively, contact Joshua Youngkin, Program Officer in Public Policy and Legal Affairs at the Discovery Institute:**

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<sup>i</sup> See Jonathan Wells, “An Evaluation of Ten Recent Biology Textbooks: A Report for the Center for the Renewal of Science and Culture” at <http://www.discovery.org/a/480>.

<sup>ii</sup> See for example David W. Deamer, “The First Living Systems: a Bioenergetic Perspective,” *Microbiology & Molecular Biology Reviews*, Vol. 61:239 (1997); Adam P. Johnson, H. James Cleaves, Jason P. Dworkin, Daniel P. Glavin, Antonio Lazcano, Jeffrey L. Bada, “The Miller Volcanic Spark Discharge Experiment,” *Science*, Vol. 322:404-405 (October 17, 2008); Kevin Zahnle, Laura Schaefer, and Bruce Fegley, “Earth’s Earliest Atmospheres,” *Cold Spring Harbor Perspectives in Biology* (2010); Dante Canil, “Vanadian in peridotites, mantle redox and tectonic environments: Archean to present,” *Earth and Planetary Science Letters*, Vol. 195:75-90 (2002); Deborah Kelley, “Is It Time To Throw Out ‘Primordial Soup’ Theory?,” NPR (February 7, 2010); National Research Council Space Studies Board, *The Search for Life’s Origins* (National Academy Press: Washington D.C., 1990).

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[http://www.metacafe.com/watch/4165203/whale\\_evolution\\_vs\\_population\\_genetics\\_richard\\_sternberg\\_phd\\_in\\_evolutionary\\_biology/](http://www.metacafe.com/watch/4165203/whale_evolution_vs_population_genetics_richard_sternberg_phd_in_evolutionary_biology/); Neo-Darwinism Vs. Whale Evolution - Part 1 - Richard Sternberg, at  
[http://www.metacafe.com/watch/5263733/darwinism\\_vs\\_whale\\_evolution\\_part\\_1\\_richard\\_sternberg\\_p/](http://www.metacafe.com/watch/5263733/darwinism_vs_whale_evolution_part_1_richard_sternberg_p/); Neo-Darwinism Vs. Whale Evolution - Part 2 - Richard Sternberg, at  
[http://www.metacafe.com/watch/5263746/neo\\_darwinism\\_vs\\_whale\\_evolution\\_part\\_2\\_richard\\_sternberg/](http://www.metacafe.com/watch/5263746/neo_darwinism_vs_whale_evolution_part_2_richard_sternberg/)

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<sup>xii</sup> See Michael S. Y. Lee, “Molecular Phylogenies Become Functional,” *Trends in Ecology and Evolution*, Vol. 14: 177 (1999).

<sup>xiii</sup> Many of the examples cited in the book are examples of “vestigial” organs have turned out to have function and are not in fact vestigial. For example, extensive evidence of function has been found for the appendix. See Martin, Loren G., “What is the function of the human appendix?” *Scientific American* (October 21, 1999), at <http://www.sciam.com/article.cfm?id=what-is-the-function-of-t> and Bollinger, R. Randal, et al., “Biofilms in the large bowel suggest an apparent function of the human vermiform appendix,” *Journal of Theoretical Biology*, Vol. 249:826-831 (2007); Duke University Medical Center, “Appendix Isn’t Useless At All: It’s A Safe House For Good Bacteria,” *ScienceDaily* (October 8, 2007), at <http://www.sciencedaily.com/releases/2007/10/071008102334.htm>. Likewise, Futuyma mentions “pseudogenes” as an example of vestigial or fossil genes, but two leading evolutionary biologists found that “pseudogenes that have been suitably investigated often exhibit functional roles, such as gene expression, gene regulation, generation of genetic (antibody, antigenic, and other) diversity. Pseudogenes are involved in gene conversion or recombination with functional genes. Pseudogenes exhibit evolutionary conservation of gene sequence, reduced nucleotide variability, excess synonymous over nonsynonymous nucleotide polymorphism, and other features that are expected in genes or DNA sequences that have functional roles.” See Evgeniy S. Balakirev, and Francisco J. Ayala, “Pseudogenes, Are They ‘Junk’ or Functional DNA?,” *Annual Review of Genetics*, Vol. 37:123–51 (2003). For a pro-ID discussion of difficulties that Darwinists encounter when using vestigial organs or psuedogenes to argue for evolution, see William Dembski and Jonathan Wells, *The Design of Life: Discovering Signs of Intelligence in Living Systems* 131-136 (Foundation for Thought and Ethics, 2008). Futuyma also mentions the panda’s thumb as an alleged example that is “poorly engineered,” but the panda’s thumb has in fact been reported to be an elegant design that “enabl[es] the panda to manipulate objects with great dexterity.” See Hideki Endo, Daishiro Yamagiwa, Yoshihiro Hayashi, Hiroshi Koie, Yoshiki Yamaya, Junpei Kimura, “Role of the giant panda’s pseudo-thumb,” *Nature*, Vol. 347:309-310 (January 28, 1999).

<sup>xiv</sup> Sylvia S. Mader, *Biology*, p. 278 (10<sup>th</sup> ed. 2010).

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<sup>xv</sup> See Michael S. Y. Lee, “Molecular Phylogenies Become Functional,” *Trends in Ecology and Evolution*, Vol. 14: 177 (1999).

<sup>xvi</sup> Jon Cohen, “Relative Differences: The Myth of 1%,” *Science*, Vol. 316:1836 (June 29, 2007).

<sup>xvii</sup> Charles Darwin, *The Origin of Species*, p. 66 (J. W. Burrow eds., Penguin Group 1985) (1859).

<sup>xviii</sup> See Jonathan Osborne, “Arguing to Learn in Science: The Role of Collaborative, Critical Discourse,” *Science*, Vol. 328 (5977): 463-466 (April 23, 2010).

<sup>xix</sup> See National Science Board, “The Science and Engineering Workforce: Realizing America’s Potential,” p. 7 (August 14, 2003) at <http://www.nsf.gov/nsb/documents/2003/nsb0369/nsb0369.pdf> and National Science Foundation, “An Emerging and Critical Problem of the Science and Engineering Workforce: A Companion to Science and Engineering Indicators 2004” (2004) at <http://www.nsf.gov/statistics/nsb0407/nsb0407.pdf>.

<sup>xx</sup> Many authorities recognize this problem. For one example, see *America’s Lab Report: Investigations in High School Science*, p. 1 (National Research Council, 2006).