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ABSTRACT

In 1985, People for the American Way released its first review of biology textbooks that was inspired by the ongoing controversy over whether or not (and how) evolution should be taught in public school classrooms. The purpose of this review is to gauge how successful the response of educators and scientists have been at convincing publishers that teachers, parents, and state education leaders want biology textbooks that do not compromise science for sectarian ideology or confuse scientific process with religious conviction. In addition, this review is designed to assist textbook selection committees as they choose the next generation of biology texts for their schools. This publication contains the following: (1) findings from this review; (2) selection criteria concerning the treatment of evolution; (3) selection criteria concerning the treatment of the nature of science; and (4) individual reviews of nine biology textbooks published from 1987 to 1991 for use in secondary school classrooms. (CW)

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A joint project of the
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National Center for Science Education is a non-profit science education membership organization promoting evolution education and education in the nature of science.

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PREFACE

In 1985, People For the American Way released its first review of biology textbooks, *A Consumer's Guide to Biology Textbooks* by Wayne A. Moyer and William V. Mayer. That review was inspired by the ongoing national controversy over whether or not, and how, evolution should be taught in public school science classes. The immediate battle was the Texas state textbook adoption process, which had previously -- and damagingly -- been long dominated by proponents of Biblically inspired "creation science."

Their influence was reflected in the textbooks. A study in 1984 by Dr. Gerald Skoog (one of the reviewers in this report) documented a marked decrease in the coverage of evolution in science textbooks between 1973 and 1983. In our 1985 report, we found that one-sixth of the books we reviewed made no mention whatsoever of evolution and fully half of the books offered only a diluted account, weakened by qualifiers such as the "Texas disclaimer." Texas required every textbook that covered evolution to state that evolution is "theoretical rather than factual," and that it is "only one of several explanations of the origins of humankind," leaving students to assume that evolution, the cornerstone of biology, is of questionable validity.

This July, and again in November, Texas will decide which of the new generation of biology books will be used in the state's public schools. As in the past, because of the sheer size of the Texas market, the books developed for use in the Lone Star state will be sold in the rest of the nation as well.

In the five years since our last review, the battle over biology books has continued unabated -- even intensified. But instead of dominating the debate, as they had in the past, the Creationists have been answered by a chorus of organizations and individuals including the National Center for Science Education (NCSE), People For the American Way, and countless scientists and educators around the nation.

The purpose of this review is to gauge how successful this response has been at convincing publishers that teachers, parents, and state education leaders want biology textbooks that do not compromise science for sectarian ideology or confuse scientific process with religious conviction. In addition, this review is designed to assist textbook selection committees across the country as they choose the next generation of biology texts for their schools.

The Texas and California Battlegrounds

In Texas and California, a new generation of Religious Right leaders and organizations are continuing a campaign for Creationism that had been spearheaded for the past 20 years by Texans Mel and Norma Gabler. In 1989, when criteria for the new science textbooks in Texas were under development, the State Board of Education for the first time *required* the coverage of evolution. This substantial progress was undermined when the director of the Texas affiliate of the National Association of Christian Educators joined the Gablers in mounting a massive eleventh-hour lobbying campaign which resulted in the addition of a qualifying phrase requiring textbooks to include, along with evolution, "other valid scientific theories, if any." The textbook adoption hearings in July and the final selection of the books in November will be the next critical forums for the Religious Right to try again to weaken the coverage of evolution.

California faced a similar challenge to science education in 1989, when the State Board of Education adopted science curriculum guidelines to be used by publishers developing new textbooks for the California market, the nation's largest. Rev. Louis Sheldon, head of the Coalition for Traditional Values, Robert Simonds, President of the National Association of Christian Educators, and local Creationist leaders launched a massive, statewide campaign to dilute the treatment of evolution and include the teaching of Creationism in the guidelines. Reverend Sheldon, claiming the support of a coalition of more than 6,000 churches, organized a media blitz around the State Board's hearings and prepared an "Evolution/Creation Packet" for use by his army of local supporters. Dr. Simonds, whose organization has been active in school censorship challenges, tried to convince the Board that "over 85% of all parents and teachers want 'Creation science' included" in public schools.

People For the American Way, NCSE, scientists, educators, parents, and clergy launched an intensive three-month effort to demonstrate to the Board that the overwhelming majority of Californians strongly supports science education free of religious dogma. The Board passed a science framework that retained a clear commitment to evolution but made concessions to the Creationists. The effect of the Board's decision will not be known until the upcoming state and local textbook selection hearings in 1991.

The textbook battles in Texas and California are far from over. In California, the science curriculum framework itself is the subject of a lawsuit on procedural grounds brought by Reverend Sheldon. The creationism proponents in that state also have vowed to carry their war into local school districts, where the ultimate decisions will be made about which books are used.

In addition, the California-based Institute for Creation Research (ICR) is presently engaged in a legal struggle for legitimacy. The ICR is mounting a lawsuit challenging a recent decision by the State Superintendent which denied the ICR state approval for its masters degree program in science. As the training academy for Creationist teachers, the ICR offers graduate programs in "Creation science" and produces Creationist books, slides, and other teaching materials for distribution across the country. State recognition of its training in "Creation science" would lend legitimacy to its programs and enable ICR-trained teachers to be placed in schools across the country.

Science and Pseudo-Science: The Battle Continues

The recent battles stem from more than a half century of war on science education waged by religious Fundamentalists intent on eliminating or severely restricting the teaching of evolution. In this effort, the Creationists have been nothing if not persistent. As soon as one anti-evolution strategy was defeated by school boards or the courts, the Creationists launched a new and slightly modified assault.

Having failed to remove evolution outright from public school classrooms, the Creationists next developed the "balanced treatment" approach, arguing that science teachers should be required to present both evolution and Creationism and let students make up their own minds about the issue. That approach was rejected in the Supreme Court's *Edwards v. Aguillard* decision in 1987, so the Creationists are trying to circumvent the Court decision by calling for "science curriculum enhancement," an effort to have Creationism introduced in supplementary science materials. In addition, they have increased their efforts to pressure state textbook selection committees and local school boards to "expand" the science curriculum, and to pressure teachers to include Creationism in the science classroom.

In Alabama, pressure from Creationists led the state superintendent of education to send a letter to school officials advising them that teachers could supplement their science curriculum "with the presentation of various scientific theories about the origins of life." This precipitated a controversy in 1990 over the introduction of a Creationist text called *Of Pandas and People* as "curriculum enhancement," foreshadowing what could well be the Creationists new line of assault. *Of Pandas and People* does not directly refer to Creationism, but captures the same idea in its concept of "intelligent design" and uses arguments identical to those of the Creationists.

Pandas was initially denied consideration for adoption by the state textbook committee. However, after pressure from Creationists, including the book's publisher and members of the Eagle Forum, Concerned Women for America, and the National Association of Christian Educators, the state board of education was prompted to reconvene the state textbook committee for an unusual public hearing to consider *Pandas* for use as a supplemental tenth-grade text.

Seeking to circumvent normal adoption procedures, Creationists hoped to set a precedent in Alabama by obtaining state sanction for the use of a Creationist text in public school science classes. The imprimatur of the Alabama state board of education would have made it easier to sell *Pandas* in other states. As the book's publisher put it, "We want this to pass in Alabama so when we go into other states we have this success behind us." This strategy backfired, however, when People For, NCSE and other scientists and educators mobilized against the book. Dismayed by the opposition to the book and faced with certain defeat, the publisher abruptly withdrew it from consideration.

Evolution and The Nature of Science: Two Elements of Scientific Literacy

This review focuses on two central and interrelated issues that have been the object of both confusion and deliberate distortion: evolution and the nature of science. Creationists perpetuate confusion about what is and is not scientific by mischaracterizing science and scientific theories. They seek to discredit evolution on the grounds that it is merely a "theory," using the term as though it were synonymous with "hunch" or "guess." They thereby betray either their ignorance about the nature of science or a penchant for distortion.

The theory of evolution is the predominant organizing principle of biology, without which the subject becomes nothing more than a list of interesting observations. These reviews examine each textbook not only for thorough coverage of evolution -- decidedly lacking in the textbooks reviewed five years ago -- but also for the integration of evolution throughout the entire book, scientifically accepted definitions of key terms, and a forthright, unqualified discussion of the topic.

The textbooks' treatment of the nature of science is also evaluated because the creationism controversy is fueled, in part, by ignorance about how science works. Science is not an authoritarian exercise, a quest for simple right/wrong or true/false answers. Rather, it is an ongoing process of exploration based on empirical data. Scientific theories are neither dogma nor mere "hunches." They are comprehensive explanations of natural phenomena, built on evidence and subject to refinement, expansion, or replacement, as knowledge accumulates. The textbooks are assessed for how well the methods and processes of science are explained, and how clearly they distinguish between legitimate scientific methods and pseudo-scientific approaches. Reviewers also looked to see if different types of scientific research are described and if evidence is carefully presented for competing scientific explanations.

Findings: Evolution

The principal finding of our reviews is positive: evolution is back in biology textbooks in an unabashed and uncompromising way. The contrast with our findings five years ago could not be more dramatic. In 1985, publishers practiced self-censorship, diluting evolution or omitting it altogether. In 1990, all nine books reviewed present in-depth coverage of evolution across a wide range of topics in biology. For now, the "dumbing-down" of evolution has stopped; these texts have been "smartened-up."

We awarded letter grades to each of the books. The three books receiving an "A" -- Prentice Hall's *Biology,* Heath's *Biological Science: A Molecular Approach,* and Kendall Hunt's *Biological Science: An Ecological Approach* -- integrate evolution as an organizing theme in biology, as our scientists recommend. Most of the others raise evolution throughout the text so that students recognize its centrality to biology. Only Prentice Hall's *Biology: The Study of Life* and Addison Wesley's *Biology: A Systems Approach* separate the topic from other sections, allowing the teacher to easily delete evolution from the course. The timidity with which publishers used to skirt around the "e-word" is largely gone. Occasionally, a textbook qualifies a statement regarding evolution with phrases such as "some scientists believe," but today this is the exception rather than the rule. Indeed, in a discussion of pseudo-science, Heath's *Biological Science: A Molecular Approach* uses the concept of "creation science" as an illustration, which would have been unthinkable in the climate of five years ago.

Why the turn-around? The experience of Kenneth Miller, the author of one of our "A" textbooks, Prentice Hall's *Biology*, provides an important clue. Dr. Miller was apprehensive about writing a textbook only to have coverage of evolution stripped out by the publisher. When he raised the issue with officials at Prentice Hall, they assured him that he was free to include evolution in any way he thought appropriate. The publishers noted that, unlike in the past, there is a market today for strong coverage of evolution. In addition, they knew that if evolution were "dumbed-down" in the new textbooks, the publisher would be sharply criticized by teachers, scientists, anti-censorship groups and parents for caving-in to Creationists. In short, the efforts by People For, the NCSE, and teachers and parents across the country throughout the past five years have helped turned the tide. These publishers now know that the public demands that science, not religion, be taught in science classes.

Findings: Nature of Science

The disappointing news in this study is that the presentation of the nature of science is still generally inadequate. The critical distinctions between an hypothesis and a theory are blurred in some of the texts. Opportunities to illustrate various scientific methodologies used in building theories are often missed. In addition, science is too often presented as a rigid process leading to the "right" answer. Students may get the impression that science is a series of facts, rather than an organized method to observe and explain the natural world.

Biology is often the last science course that students take, so their exposure to *how* science works is as important as their substantive education in biology. The battle over evolution and creationism illustrates a troubling ignorance about the nature of scientific knowledge and the process by which science arrives at conclusions. The three "A" textbooks are exemplary in their treatment of science, but the six other texts still can be improved.

Conclusion

The battle over non-sectarian science education is not over, but a significant victory has been won. All nine of the textbooks we reviewed are substantially better in their coverage of evolution than their predecessors five years ago. But still, the critical test will be whether these books survive the selection processes in several key states in the next few years, and whether the progress reflected in these texts continues. Several of these textbooks, particularly those that integrate evolution throughout the material, undoubtedly will draw vociferous opposition from Creationists and other Religious Right activists. As in the past, they will pressure textbook selection committees in Texas and California and other states across the country to compromise science education.

The stakes in this battle are high. Surveys conducted by the Public Opinion Laboratory of Northern Illinois University find that American students score worse or no better in science than their counterparts in the United Kingdom, Ireland, Spain, Canada, and South Korea. American students rank last in their grasp of biology. The studies also find that only 6 percent of Americans are science-literate, with 36 percent saying that astrology is scientific and 55 percent not knowing that the earth revolves around the sun once a year. Only 37 percent of Americans know that humans and dinosaurs did not co-exist. If we are to overcome what many have called an appalling level of scientific illiteracy among our students, we must ensure that science is untainted by religious dogma.

We congratulate these publishers for improving the coverage of evolution in these nine textbooks and resisting self-censorship of this critical topic.

Arthur J. Kropp
President
People For the American Way

REVIEWERS' FINDINGS

The nine textbooks under consideration for adoption in Texas were evaluated for their treatment of evolution and the nature of science. These two topics are the most important elements in a biology textbook. Without a complete, honest and accurate treatment of evolution and science as a way of knowing, a book is simply not acceptable. The choice of these criteria also reflects our concern with the continuing effort by Creationists to inject their religious ideas into the science curriculum, and the problem of 'science illiteracy," in part fueled by Creationists, among students and the general public alike. The decline of science education in the past twenty years is directly related to the treatment of these two topics in science textbooks.

There are, of course, other criteria that teachers and administrators will consider, such as the quality of the writing, the ratio of space given to photographs versus text, the appropriate choice and complete development of topics, and the overall ability of the book to engage students. These important issues are not the primary focus of this study.

Evolution

We are happy to report that the tide has turned away from publisher self-censorship. All nine books cover evolution to a greater extent than their predecessors reviewed five years ago. They present the mechanisms, patterns, and theories of evolution, fulfilling the adoption criteria set forth in the Texas State Board of Education Proclamation 66. The requirement stated in Process Skills 6.3 to present scientific evidence of evolution and "other reliable scientific theories, if any" is satisfied. The texts give appropriate evidence of evolution, but properly ignore non-scientific views such as "scientific creationism," "abrupt appearance," and "intelligent design."

Several of the books incorporate evolution as an organizing theme, but some still relegate evolution to its own, private, easily-skipped section. The textbooks include evolution across a wider range of topics in biology than in most texts for the past twenty years.

Still, the perfect book has not been written. All the books do not treat evolution completely or even accurately. There is still much to be done to insure that *all* biology textbooks present evolution as the organizing theme and present it correctly. Nevertheless, great strides have been made. The offensive "some scientists believe" qualifications still appear occasionally when evolution is discussed (though not in any other scientific area), but the timidity with which publishers used to skirt around the "e-word" is gone. We congratulate these publishers for responding to the educational and scientific communities' complaints about self-censorship practices.

Nature of Science

Although evolution is covered substantially better in the books, the presentation of science as a way of knowing is still disappointing in many. Science is too frequently presented as a lock-step series of procedures one must follow to get to the "right" answer. It is often characterized as a process performed by a priesthood of experts in white coats rather than "organized common sense" accessible to all. The net effect is that many of these books will lead students to think that science consists of memorizing lists of facts or repeating rigid procedures, rather than an approach to explaining the natural world.

How Did They Do?

On the basis of their treatment of both evolution and the nature of science, we give an "A" to Heath's *Biological Science: A Molecular Approach,* Kendall Hunt's *Biological Science: An Ecological Approach,* and Prentice Hall's *Biology;* a "B+" to Heath's *Biology,* Holt, Rinehart and Winston's *Modern Biology,* and Merrill's *Biology: Dynamics of Life;* a "B-" to Holt, Rinehart and Winston's *Biology Today* and Prentice Hall's *Biology: A Study of Life*; and a "C+" to Addison Wesley's *Biology: A Systems Approach.*

The "A" books were exemplary in the extent and accuracy of their treatment of both criteria. Because evolution is an organizing theme throughout these books, however, they are likely to be severely criticized by the anti-evolutionists. But, as before, these individuals are out of step with modern science, and their opinions should be received courteously and then rejected.

It is significant that evolution is treated as a matter-of-fact in all three "A" books. This is the way scientists approach the subject but, until now, it has not been the approach of most textbooks. The tide has definitely turned.

Eugenie C. Scott, Ph.D.
Executive Director
National Center for
Science Education

CRITERIA FOR TREATMENT OF EVOLUTION

There is no scientific controversy over whether or not evolution has taken place. There is considerable controversy over *how* this change has occurred: what the specific relationships among fossils are, and what mechanisms and processes were involved in producing the present-day earth. Evolution as change through time should be distinguished from the mechanisms and processes of evolution, so that students don't confuse the rejection of a mechanism of evolution with the rejection of the idea that evolution has taken place. Textbooks should help dispel this confusion by discussing evolution in a full and forthright manner. The following criteria were used to assess each book's coverage of the theory of evolution.

1. Evolution is integrated throughout the text.

The theory of evolution is the predominant organizing principle of biology, without which it becomes merely a list of interesting observations. As a comprehensive -- though not complete -- explanation of how life develops and changes, evolution makes biology understandable, linking together our knowledge of all forms of life. Therefore, a text should refer regularly to evolution during the discussions of most topics, and not isolate evolution in a single chapter. For example, topics such as taxonomy, homology, ecology, and anatomy should logically include discussion of evolution.

2. The evidence for evolution is fully presented.

Textbooks should demonstrate that evidence for evolution comes from a variety of sources besides the fossil record: comparative anatomy, embryology, biochemistry, and biogeography (the distribution of plants and animals). The principles of stratigraphy and the evidence for phylogenetic relationships should be discussed. Biochemistry has added greatly to our understanding of evolutionary biology, and students must become aware of this new source of evidence.

3. The mechanisms by which evolution proceeds are presented.

Natural selection is the major mechanism of evolution, and critical as well to the concept of adaptation. Darwinian natural selection should be presented fully and accurately, and examples of natural selection provided. The concepts of speciation, adaptive radiation, and punctuated equilibria should be fully explained. The role of isolation in species formation should be included. The text should also consider the implications for evolution of genetics. Mutations are the ultimate source of variation, and neutral mutations, gene and chromosome duplications, and recombinations are sources of variation which natural selection works upon.

4. Human evolution is discussed fully and fairly.

Human evolution should be presented in a straightforward way, with ample evidence and no equivocation or attempts to separate humans from the rest of evolution. Humans and modern apes should be presented as having a common ancestor. When ancestral lineages are described, the evidence supporting them should also be presented. The evidence for human cultural evolution and its implications should be discussed. The textbook should make clear that human evolution, like all evolution, is a continuum. Human evolution should be listed in the index.

5. The development and early evolution of life on earth is discussed.

In addition to presenting accurately the hypothesized sequence of the origin of life, the book should emphasize that evolution is not just a sequence of unrelated events. It is insufficient to present stages without describing the continuity of life. Thus, the book should indicate that organic compounds could spontaneously form molecules, that complex molecules could self-assemble into membranes, that prokaryotic organisms could evolve through natural selection into eukaryotic organisms, and that natural selection could produce heterotrophs from autotrophs. Information about the nature of Precambrian life, as deduced from fossils, should be included.

6. Definitions of key terms are clear and thorough and conform to accepted scientific usage.

Evolution should be clearly and fully defined early in the text. Adequate definitions of the key terms and concepts (such as natural selection, adaptive radiation, punctuated equilibria, etc.) necessary to a thorough understanding of evolution should also be provided. The text should strive to strike a balance between supplying the vocabulary students need for a good understanding of the subject and overwhelming them with a list of technical terms.

7. The history of the development of evolutionary theory is included.

Because of his central place in the development of the theory of evolution, Charles Darwin should be discussed. The text should present an accurate depiction of his life and, most importantly, of the observations and process of reasoning that led to his ideas about evolution through natural selection. The influence of other scientists (Lamarck, Wallace) should be noted as well.

CRITERIA FOR THE TREATMENT OF THE NATURE OF SCIENCE

Science is not only a body of knowledge, but also -- and perhaps more importantly -- it is a way of acquiring knowledge. In addition to describing the knowledge that comprises a given field such as biology, science texts must accurately convey the nature of scientific knowledge and how science arrives at conclusions.

"Truth" in science, as opposed to religious or revelatory truth, is never absolute. Scientific methods lead to explanations that can be logically related to other explanations, and can generate new questions to be asked and answered. Science examines and tests data -- empirical evidence -- about natural phenomena. Mistakenly thinking that science is the search for "The Truth," students are often surprised to learn that some scientific laws and theories have changed over time. It is the nature of scientific explanations to change, which is why hypotheses are never considered "proven," but rather are rejected or corroborated. Although all scientific explanations are in some sense tentative, the rigorous investigation required by the scientific method allows us to have confidence in scientific statements. Some explanations, such as the theory of evolution, have been tested again and again, some literally for centuries, without rejection.

The following criteria were used to assess each textbook's coverage of the nature of science and scientific methods.

1. Science is presented as an ongoing exploration, not as dogmatic truth.

The text should make clear that science is not an authoritarian exercise. A scientific explanation isn't accepted merely because someone famous proposed it. Scientists develop explanations about natural phenomena based on observation, reason, and empirical testing.

The text should not equivocate about solidly established scientific findings and should accurately describe how scientists reach their conclusions. Terminology such as "some scientists believe," which implies that science is some sort of opinion poll among scientists, is not an acceptable way to express scientific work. The word, "believe" is not appropriate for a science text, as it connotes a conclusion not based on empirical evidence, as science must be. It is best to present scientists doing science by using verbs like "conclude," or "hypothesize," or "infer," or "deduce," and ideally, with reference to the observations or reasoning that lead them to these conclusions.

2. The methods and processes of science are explained clearly and fully.

Elements of the hypothetical-deductive method are basic to most research, and should be described correctly in a textbook. The goal of science is to build explanations, or theories, of the natural universe. There are many scientific methods that are used to do this, and textbooks should not present science as a uniform methodology.

Observations of the natural world generate questions about natural phenomena. An hypothesis, or preliminary statement about the relationship between things, is proposed and tested against nature, using a number of different methodologies. An hypothesis can be confirmed or rejected. Confirmed hypotheses are used to generate new hypotheses to be tested against the world of nature, and the cycle of science continues.

A theory is a complex, abstract explanation based upon confirmed hypotheses. Theories themselves are ranked, some being limited and quite simple, while others are extremely abstract and complete. The more complex the theory, the less likely it will be rejected by one or a few tests, and the greater its utility to propose new hypotheses to be tested. Examples of vigorous theories that have stimulated much research are Darwin's natural selection theory, and the asteroid extinction theory explaining the demise of the dinosaurs.

Where there is healthy controversy in a field, students should be exposed to it. At any given time in any active science, there will be alternate explanations of many phenomena. But the text should not merely list the two explanations; it must also include at least some of the evidence for each. Otherwise, students may fail to understand that competing explanations are based on data and are not simply different opinions to choose among.

3. Different types of scientific research design are described.

Textbooks should describe the various research methodologies used in building theory, and not limit this discussion to a presentation of the experimental method. Much of biology (and other sciences as well) uses observational experimentation, where variables are "controlled" naturally rather than by the experimenter -- and sometimes without "experiment," as it is generally understood. Some hypotheses are tested through description. Without some description of nonexperimental research designs, students may get the erroneous idea that historical sciences like evolution, geology, and astronomy aren't really scientific because "no one was there in the past to see it happen."

4. The text consistently uses accurate terminology that conforms to accepted scientific usage.

The text should provide full explanations for all technical terms, with special care taken to encourage a clear understanding of the terms "hypothesis" and "theory." An hypothesis is a testable statement that can be supported (not "proven") or rejected. But an hypothesis should not be presented as a "hunch" or "guess" because those terms do not connote the empirical, observation-based nature of science. Scientists don't sit in their offices and "guess" about nature. They form hypotheses based on some prior empirical knowledge and then they test -- and retest -- those hypotheses, refining them in the light of new information. The empirical basis of science must be emphasized.

The term "theory" is understood very differently by scientists and the general public. To nonscientists, theories often are also equated with hunches, guesses, and speculations. On the contrary, theory formation is the goal of science. Theories are explanations of natural phenomena. They are composed of corroborated hypotheses and observations that are often tied to other theories. One philosopher of science has written of theories being composed of and testable in "bundles." Because they are abstract and composites of other ideas, theories are not usually directly tested, although parts of them can be. It is rare, therefore, that a "whole" theory is rejected, though parts logically connected to it can be rejected. It is expected that theories will change through time. Natural selection is an example of a theory consisting of several components, some of which have been modified over the years.

In general, the word "theory" should be reserved for the abstract explanations that incorporate many observations and confirmed hypotheses. An hypothesis is not a theory, as an hypothesis is directly testable and potentially rejectable. Theories generally are not.

TITLE: *Biology: A Systems Approach*
AUTHORS: Edward J. Kormondy and Bernice E. Essenfeld
PUBLISHER: The Addison-Wesley Publishing Co., 1988
REVIEWED BY: Wayne A. Moyer

GENERAL

The first unit spans 86 pages and introduces 92 new vocabulary words, as listed in the chapter summaries. The first chapter --"The World of Life" -- amounts to an executive summary of the rest of the book, which probably accounts for the excessive number of new words. Concepts are introduced out of context and dropped without further development, making the chapter extremely difficult to read and understand. The wise teacher will skip it entirely.

Chapter 2, "Classification of Living Things," continues the pace set in chapter 1 with a forced march through the phyla, including all five kingdoms and viruses, in 55 pages. The intent is to provide students with a basic understanding of earth life so they may appreciate the following chapters that introduce examples of organ systems from various phyla. However, the authors fail to provide the evolutionary framework that is essential for understanding why life is so varied yet so similar. The alert teacher will have to supplement this chapter with extensive discussion: "Why is it possible to classify organisms into such neat, nesting categories?" "How can we explain the diversity of life on this planet?"

The teacher should also correct the persistent misuse of scientific name when species name is meant. *Felis domesticus*, for example, is the two-part species name for the house cat. Felis is the genus name, while domesticus is the trivial name; together they make up the binomial species name. It is a small point, but a science textbook should follow accepted usage.

Units III through V present a thorough coverage of the major concepts of biology, from the point of view of comparative anatomy and physiology. For example, Chapter 7 treats gas exchange, beginning with an overview of respiration, then moving to respiration of bean plants, paramecia, hydra, earthworms, grasshoppers and humans. This sequence is repeated for each life process. The systems approach offers many advantages over a phylogenetic approach, such as demonstrating the unity of life. However, care must be taken to point out the evolutionary relationships that underlie this unity. The authors have failed to do this, leaving the task to teachers.

EVOLUTION

The unit entitled "Continuance and Change" opens with a well written chapter on Mendelian genetics, followed by one on chromosomal genetics that traces the fascinating story of modern genetics from Sutton to genetic engineering. These chapters set the stage for the presentation of evolutionary theory.

The authors establish that all life comes from previous life, tracing the work of Francesco Redi and Pasteur relating to spontaneous generation, and then consider the heterotroph hypothesis. Fossil evidence for changing life forms follows, thus establishing the basis of evolutionary theory: all life comes from previous life, but since life in the past was different from life today, evolution must have occurred. Support for a hypothesis of evolution is briefly --too briefly--presented, including short paragraphs on homology, embryology, vestigial organs, body chemistry, and the role of isolation in promoting evolutionary change. The chapter concludes with a decent review of natural selection, both short term (microevolution) and long term (macroevolution). Punctuated equilibrium is compared with Darwin's gradualism.

This section contains a very misleading paragraph that begins, "[s]udden appearance of new species occurred in the early development of mammals." "Sudden" in geological terms means a million years or so! Unfortunately, the authors fail to explain this, leaving students with a serious misconception. The chapter concludes with a solid presentation on human development, including an excellent summary of hominid evolution.

NATURE OF SCIENCE

The term "theory" is introduced in the context of describing cell theory. Yet the term is not defined, and the description leaves the student with the mistaken notion that a theory is just a grown-up hypothesis. This view is preserved in the Glossary where theory is defined as "a general statement explaining a set of facts which is supported by scientific evidence." Nothing is included about the predictive power of cell theory, or its relative certainty. Is it any wonder, then, that students leave biology--the last science course most of them will ever take--with the naive view that a theory is only a tentative, unproven explanation? To their credit, the authors do present experimental evidence for scientific conclusions at various points.

The scientific method is described in one page of text, by considering the question, "Can a cell live without a nucleus?" A "controlled experiment" is then suggested, consisting of removing nuclei from 20 cells and not from 20 others. Unfortunately, the correct control would be to "sham operate" on each control cell, to duplicate the trauma of removing nuclei from the experimental cells. (This same error appeared in the 1984 edition). The authors miss a wonderful opportunity to explore the history of how knowledge about nuclear function was painstakingly built up, beginning with experiments similar to the one described.

Overall, experimental methods, and the nature of scientific knowledge, are very poorly presented in this book. Supplementary material will be required by teachers if their students are to leave biology with any understanding of these essential concepts.

SUMMARY

Although this is a well written biology textbook, there are problems in both the presentation of evolution and the nature of science, as noted above. These problems should have been corrected early in the production process by the publisher, and certainly after the first edition was published and at least one reviewer pointed them out.

TITLE: *Biology*
AUTHORS: James E. McLaren, Lissa Rotundo, and 'Laine Gurley-Dilger
PUBLISHER: D.C. Heath and Company, 1991 Teachers Edition
REVIEWED BY: Eugenie C. Scott

EVOLUTION

Integration Throughout the Text

Heath's *Biology* gets high marks for an uncompromising attitude towards evolution, a topic which is not relegated to a terminal chapter, but which runs through much of the book. In the teachers' introductory material, the books says, "[w]hile evolution is not formally introduced in the text until Chapter 14, much of the material in earlier chapters can be presented as examples of adaptation or of relationships that imply evolution. Many of the examples of unity within biology are easily interpreted as an indication of evolutionary relationships." Bravo!

The chapter on taxonomy has a good evolutionary orientation. There are also references to evolution throughout, for example, the seed plants chapter where the authors note that gymnosperms evolved earlier than angiosperms. There are also frequent references to evolution in the chapters on animals, for example, a reference to arachnid evolution being characterized by reduction in body segmentation.

In general, this book's treatment of evolution is much more straightforward than most of its predecessors.

Evidence for Evolution

We do not see any of the "weasel words" textbooks often substitute for evolution: "development", "change through time" and so forth. In fact, Unit 2 is titled "Genetics and Evolution." Genetics is presented after students have been introduced to DNA, mitosis, and cell division, thus students understand the principles of heredity before they are introduced to evolution. This approach tends to defuse evolution by making it the logical consequence of principles of inheritance that students find noncontroversial.

A section called "Evidence for Evolution" lists most of the usual topics (fossils, anatomy, embryology, molecular biology) but omits biogeography. Fossils are described, and radiometric and other means of dating are discussed. Following a section on homology of structure, there is a good tie-in with material learned earlier about the structure of protein: "Why can the sequence of nucleotides in genes also be used to determine evolutionary relationships?"

Students learn that there are single-celled fossils as well as fossils of more complex forms, and the Precambrian is presented not as devoid of fossils, but rather as the period in which most of the major invertebrate forms first appeared. The early Paleozoic (or Cambrian) "explosion" of animal fossils is treated correctly as having taken place only *relatively* suddenly, over millions of years. Fish appear before amphibians, which appear before reptiles; it is not an instantaneous appearance of higher taxa as often presented by "scientific" creationists. Diagrams on vertebrate evolution following chapter 36 are especially good in showing when various forms within classes appear. The authors also assist students' understanding by making explicit that the "explosion" was an adaptive radiation, thus reinforcing the term learned earlier.

To Heath's credit, chapters on major taxa include evolution along with anatomy and other characteristics. However, many good opportunities are missed. Neither the section on reptiles nor the one on mammals includes a discussion of the mammal-like reptiles, one of the clearest and best documented examples of evolution in the fossil record. The chapter on mammals talks about a "definite mammal" occurring in the Jurassic period and its evolution into other forms, but there is no explicit connection between reptiles and any other mammals except for a vague statement about "some reptiles were becoming mammal-like." It is not enough to just *say* that organisms evolved; a textbook has to *show* connections between taxa if evolution is to be conveyed correctly.

Mechanisms of Evolution

Natural selection is correctly defined in the glossary as a "process by which the environment allows only the better adapted organisms to survive and reproduce." The text introduces natural selection historically, in a section discussing Darwin, but then makes the concept relevant by showing natural selection in action today in a discussion of the peppered moth. There is a good link to the Hardy-Weinberg principle learned earlier in the section on genetics. Natural selection is placed in the context of modern genetics as a disrupter of equilibrium.

Speciation is presented in the context of natural selection, and the major concepts of geographic isolation and reproductive isolation are clearly presented. It is noted that physical isolation is not necessary to bring about reproductive isolation.

The treatment of adaptive radiation in the text could be clearer, though it is properly defined in the glossary. Students may not realize from the text that adaptive radiation is usually applied to the production of *many* species, moving into a variety of niches. Perhaps the example of the Galapagos finches will help clear this up. The text discussion -- though brief -- includes the importance of a "new environment" (by which they mean new niches) though the glossary definition does not. Adaptive radiation is also recalled later in the book in the evolution sections, for instance, when the Paleozoic "explosion" is discussed. This is good; students don't learn a concept and then never hear of it again.

Punctuated equilibria is discussed briefly in a short section in Chapter 14, but the treatment may confuse students. Authors discuss the episodic nature of the fossil record as stimulating the development of the theory, which is commendable. The section states, confusingly, that "the answer may be that both mechanisms contribute differently to the process of evolution." Neither of them contribute to the "process" of evolution, though both of them are *modes* by which evolution can take place. If they are trying to say that evidence exists to support both views, they haven't quite done so.

The text does a good job of tying modern genetic theory to evolution. Both in the text itself and in the chapter review questions, students are led to relate genetic principles to evolutionary ones.

Definitions

At the beginning of Chapter 14, "Evolution," the authors define evolution as the "process by which existing species change or branch into new species," which is an acceptable definition. The passage communicates the idea of descent with modification in an example: "Thus eagles and hawks resemble each other because they both evolved from some pre-existing hawklike species."

History of Evolutionary Thought

The history chapter includes a discussion of Lamarck as an evolutionist, attempting to explain extinction, followed by a brief discussion of Darwin's development of natural selection theory. Given the importance of Darwin to evolutionary biology, this seems a rather sketchy presentation.

Human Evolution

There is an entire chapter on human evolution, more than many texts. Considering that close to a third of Americans think dinosaurs and humans coexisted, it is commendable that the book debunks that misconception. There is an informative exercise on primate anatomy structure and function, as students "remove" their opposable thumbs by taping their thumbs to their palms and try to manipulate objects. And, human evolution is in the index.

On the less positive side, Figure 16-1, a primate family tree, is likely to mislead students. Humans, chimps, gorillas, gibbons, old world monkeys, new world monkeys, lemurs and tree shrews are all given separate "branches" to a common "trunk," which might lead students to think all are equally distinct. Actually, the gibbon, gorilla, chimp and human are more closely linked to each other than to the rest, and within this cluster, the last three are quite close. The caption says, "It is thought that humans and apes evolved as separate lines" but separate from what? Other primates? Each other? The diagram will not solve the problem.

There are some other good points: the molecular taxonomy exercise using hemoglobin chains across four primates and humans is a good one, and it is important that students learn, as they do, that not all hominid fossils are part of the lineage that led to humans. Students must be brought away from the idea that evolution is a linear process. Unfortunately, there are also errors: the human pelvis does not support the internal organs (mesenteries do); none of the ape teeth are "adapted" for eating meat: apes are herbivores or frugivores with occasional omnivorousness in chimps; the definition of culture is incomplete without the addition of the idea that culture is learned "behavior patterns of a group of human beings."

But the biggest problem with the human evolution section is dullness. This "stones and bones" approach is not likely to encourage a student to be fascinated by human evolution, and may well kill any interest a student brought to class.

Origin of Life

The topic of the origin of life is covered in Chapter 15, "The History of Life." Earlier material in Chapter 2 on biogenesis is recalled to introduce the idea that at some point, life did come from non-life. Oparin and Haldane's theory of the formation of organic molecules in the earth's early seas and the later tests of it by Miller are presented, with further explanation of how these molecules could form into primitive cells. The new "clay theory" is also raised. In discussing the heterotroph hypothesis, and the evolution of prokaryotes and eukaryotes, the authors do make clear how one stage can lead to another, but they are not specific about how natural selection can explain these transformations.

The section has a lot of information, but it is crammed into a rather small space. It may be too much for students to handle. Also, the choppy sentence structure inhibits the smooth flow of ideas.

THE NATURE OF SCIENCE

Methods of Science

The text stresses that biology (or any science) is not merely a collection of facts, but a coherent whole that is best understood through looking at themes or unifying ideas that tie it together. This is a commendable position. The book adopts the thematic approach, but the critical theme of the process of science is highlighted in only three units when it should permeate the entire book.

The text does a decent job of describing the hypothetical-deductive methodology of science, noting that the scientific method includes observing, defining, hypothesis formation, testing, observing and recording results, concluding, and reporting results. It makes clear to students that the "steps listed here are frequently modified in a scientific investigation," a useful caveat. The book is careful to point out that science does not consist of lockstep procedures that produce cookbook results, and notes that many scientific developments have been produced through luck, being right for the wrong reason, and so forth.

Although it mentions alternate explanations, the book does not clarify the role of alternate theories in scientific tests because it does not reinforce the principle with examples. The book focuses mainly on "controlled experiments," only one type of research design, and neglects opportunities to discuss field research, such as when discussing the relationship between the numbers of snowshoe hares and lynx.

Presentation of Science

The text avoids authoritarianism in its presentation of science, and explains the practical problems of writing a textbook which supports conclusions with evidence: "Ideally, every statement in this text should be accompanied by supporting observations or experiments. However, if supporting information were included with each statement, it is unlikely that this text would fit into your school locker!" Still, the process of science could be brought into the description of many more discoveries than is done in this text.

The use of qualifying phrases such as "some scientists believe" is not a major problem in this book, but it does occur.

Terminology of Science

The text presents hypotheses as educated guesses, preliminary explanations, and ideas to work from. They are compared to rough sketches of an artist, with modifications expected as the work progresses. Students are told that hypotheses often have an "if...then" format, which may help them grasp the concept better. Hypotheses are treated as low level theories that explain phenomena, and that generate predictions to test, rather than being themselves testable. This may be confusing to students, as many hypotheses are themselves are testable.

The hierarchy between hypothesis and theory is not made clearly. At least the text makes explicit that theories can change through time, and that "proof" is a loaded term.

It recommends that students think of experiments as rejecting or supporting rather than "proving" hypotheses and theories, which is good.

Characteristics of Science

The empirical nature of science is assumed, but not made explicit, and although proof is discussed, "truth" is not. Reference is made to explanations changing through time, but it is not made explicit that science is self-correcting because of its characteristics of repeatability and being (ultimately) empirically based.

SUMMARY

In summary, Heath's *Biology* is quite good. Evolution runs throughout the textbook, and there are relatively few errors. Science as a way of knowing, unfortunately, is not fully integrated throughout the text and there are gaps in the way the topic is presented.

TITLE: *Biological Science: A Molecular Approach*
AUTHORS: Biological Sciences Curriculum Study
PUBLISHER: D.C. Heath and Company, Teachers Edition 1990
REVIEWED BY: Gerald Skoog

GENERAL

This 817-page textbook is made up of 6 units, 26 chapters, a 131-page section of laboratory investigations, a 30-page appendix of supplementary information, a glossary, and index. The six unit titles ("Unity and Diversity;" "Structure and Function of Cells;" "Genetic Continuity;" "Evolution: Change Through Time;" "Life Processes: Regulation and Homeostasis;" and "Organisms and Their Environment") clearly signal that this textbook is not organized for a classical study of organisms sequenced phylogenetically as done in the majority of high school biology textbooks.

The textbook has fewer vocabulary words, review questions, illustrations, photographs, and special features than most high school biology textbooks. It also attempts to cover fewer topics. As a result, space is available to treat major topics in a comprehensive manner.

EVOLUTION

Integration Throughout the Text

Evolution is identified as the first of ten major themes emphasized in the textbook. The statement of BSCS philosophy in the textbook declares that, "[t]he threads of molecular biology and the theory of evolution by natural selection tie together the chapters as the emphasis changes gradually from molecules to cells, individuals, populations, and finally to the biosphere."

Overall, the authors adhere to this philosophy. The index lists 31 references for evolution. Evolution is introduced in a variety of contexts and with different degrees of emphasis, and connections are made with evolution that are typically ignored in high school biology textbooks. For example, genetics is defined as "the branch of biology that seeks to explain biological variation -- the raw material for evolution through natural selection" and inherited features are termed "the building blocks of evolution." The authors connect evolution and behavior by stating that, "[b]ecause behavior helps an organism survive, it is closely related to the evolution of the species." In Chapter 1, the development of the theories of Lamarck and Darwin is used to illustrate the methods of science. In the process, the basis for evolutionary theory and thought is presented.

These and other examples illustrate how the presentation and organization in much of the textbook reflects an evolutionary approach.

The role of evolutionary histories and relationships in classification is emphasized. The authors state that the "classification system used most widely today considers how organisms are related, and groups them on the basis of their evolutionary history." The variation among individuals in a population and the species concept are thoroughly discussed. The importance of anatomical and chemical homologies in indicating related evolutionary ancestries, and therefore in making decisions about the classification of organisms, was noted. A two-page illustration is used to show the relationship of the five kingdoms and the many phyla. The authors emphasize that classification is an arbitrary process and that there is continued disagreement about the number of kingdoms and the criteria used to distinguish them.

Various adaptations that have evolved from reproduction are noted in Chapter 11. In the chapter titled "The New Genetics," the authors reiterate that "the genetic variation within a species provides the basis for evolution by natural selection." The authors stress that base-by-base comparisons of genes have "been useful in determining the evolutionary relationships of various groups of organisms, and they reaffirm the genetic relatedness of all life on Earth."

The evolution and presence of special plant adaptations concerned with photosynthesis are described briefly in the photosynthesis chapter. The evolution of adaptations that "favor germination only at times when survival of the seedlings is most likely" is noted. The "Focus On" feature is used in Chapters 9 and 10 to describe the evolution of mitosis and information-storage molecules, respectively. Chapter 19 includes some information about the evolution of plants and adaptations for life on land. A brief note about the evolution of gas exchange apparatus in land organisms appears in Chapter 21. The evolution of vertebrate body coverings and feathers from reptilian scales is noted. The evolution of the brain of vertebrates is discussed in some detail. In a brief discussion of evolution and behavior, the authors note that "animal behavior is a biological process with a genetic basis that is shaped by evolution." Appendix 25B describes the role of aggression in animal behavior and explains the evolutionary value of such behavior. In the final chapter, the complementarity of organisms and the environment is termed "a product of evolution through natural selection."

Evidence for Evolution

The variation in the finch population on the Galapagos Islands, the peppered moths in England, bacteria that are resistant to antibiotics, and variation in the molecules that control heredity are described as evidence of evolution in Chapter 6. In this section, which is titled "Evidence for Evolution," fossils, biogeography, homologous organs, embryological similarities, and vestigial organs are not cited as evidence of evolution as in most textbooks. However, in the chapter on classification, anatomical and chemical homologies are described as indicators of evolutionary relationships and histories.

In the chapter on human evolution, the importance of fossils in building a record of human ancestry is noted and stratigraphy, biostratigraphy, and radiometric dating are described as methods used to determine fossil age. Radiometric dating is treated comprehensively in the appendix. A discussion of extinction, with a particular emphasis on the mass extinctions of 65 million years ago, and the asteroid extinction theory appear in a chapter-ending feature.

Mechanisms of Evolution

Chapter 16, which is titled "Origin of New Species," begins with a conceptual statement that describes evolution as follows: "The history of life is not a story of unchanging species on a static planet, but rather a record of an ancient Earth inhabited by constantly changing populations of organisms. Each species is on the tip of a branching tree of life that extends far back in time. Evolution is the biological process that ties all species together."

The authors state further that "natural selection produces new species from old species" and that evolution "is the one idea that explains both the unity and diversity observed in life." Natural selection was introduced in Chapter 1 and then dealt with through the use of examples in Chapter 16. A laboratory activity presents data concerning the peppered moths in England and requires students to respond to 17 analysis questions. Additional background on Darwin's and Wallace's development of the theory of evolution through natural selection is in the appendix.

In a Chapter 6 discussion of population genetics, gene pool is defined and it is emphasized that "[p]opulations evolve, not organisms within the population." Mutatio.., migration, genetic drift, selection, and nonrandom mating are described as factors that can change the equilibrium of a gene pool. A laboratory investigation focuses on the Hardy-Weinberg principle and requires the students to calculate the allele frequency for a hypothetical population. Appendix 16B provides an in-depth description of the Hardy-Weinberg principle. Microevolution, which is defined as "the changes that occur within populations and species" and macroevolution, which is defined as "evolution above the species level" are described as useful terms that "help summarize the many processes involved in evolution." The founder effect is explained in a short feature. The role of geographical, ecological, behavioral, seasonable, and mechanical isolation in speciation is described. Triticale, desert whiptail lizards, alder and willow flycatchers, and other organisms are used as examples to show how specific isolating mechanisms can result in speciation. Adaptive radiation is described in a special feature that uses hypothetical organisms that live on a series of islands.

History of Evolutionary Thought

Lamarckian and Darwinian evolution are both explained in Chapter 1 and used to illustrate how hypotheses are tested and either rejected or confirmed. The observations and experiences that shaped Darwin's conclusions are described in Chapters 1 and 6 and in Appendix 1a. The authors note that Darwin's observations of changes in domestic species were more influential in shaping his thinking than were his observations of organisms on the Galapagos Islands. Also, this is one of the few high school biology textbooks that states that Darwin left on the voyage of the *Beagle* with the conviction "that life had originated through special creation events and that all species were fixed in form."

A three-page description and evaluation of the theory of punctuated equilibrium are given at the end of Chapter 6. The authors note that "the idea that evolution could occur by successive major changes in a brief geologic time has not been firmly established." The chapter closes with a prediction: "some biologists predict that punctuated equilibrium and natural selection will eventually become two parts of an expanded theory of evolution."

The descriptions of Lamarckian and Darwinian evolution and the theory of punctuated equilibrium are not lengthy, but the language and examples used result in clear, accurate, and easily understood explanations.

Human Evolution

The characteristics of primates and the uniqueness of humans are described in Chapter 17. Biochemical comparisons between humans and chimpanzees are noted. The authors point out that biochemical tests cannot be made on extinct species and, as a result, most of the evidence for human evolution has been derived from the physical structure of fossils. Stratigraphy, biostratigraphy, and atomic physics are described briefly as methods that are used to establish the age of fossils. The authors indicate that family trees developed from morphological evidence tend to be very similar to those developed by biochemical studies.

A concise description of comparisons of the jaws, teeth, skull, hips, backbone, femur, the shape and wear patterns of teeth, and the amount and placement of the curvature of the spine are used "to understand who our ancestors were and what they were like." A laboratory investigation requires a comparison of the skulls, pelves, and lower jaws of three different primates. A special one-page feature inserted in Chapter 17 describes and evaluates the research with mitochondrial DNA that has led to the conclusion that all modern humans descended from one female who lived in Africa about 200,000 years ago.

The second part of the human evolution chapter begins by stating that, "[t]oday anthropologists know that the human lineage began with a primate ancestor from whom various hominids evolved." *Australopithecus afarensis* is termed "the first definite hominid" in a discussion of Australopithecene fossils and their place in human evolution. The authors note the disagreement about the place of *Homo habilis* in human ancestry. *Homo erectus* is described and labeled "the first widely distributed hominid," as it spread out from Africa into southeastern and eastern Asia. The Neanderthals, their culture, and their fate are discussed. In describing the Cro-Magnons, the authors indicate that they apparently originated outside of Europe and may have replaced the Neanderthals in southwestern Asia 40,000 years ago. The chapter ends with a description of how humans have spread out over the Earth and, how at one time, many isolated groups of humans had distinct genetic variations.

Appendix 17A describes some of the evolutionary changes that took place in humans and made it possible for us to become a stable bipedal animal. Appendix 17B explains how the rebuilding of a Neanderthal fossil found in France was marked by numerous errors that led to many misconceptions about the stature, brain-size, and other characteristics of these individuals. Appendix 17C summarizes the cultural evolution of humans and concludes that "of the many upheavals in the history of the Earth, the emergence of humans is the latest and perhaps the greatest." A laboratory exercise requires the interpretation of artifacts gathered at an archaeological dig and answers 23 related questions.

The style of writing, the selection and sequencing of the content, and the directness of the authors makes the chapter on human evolution engaging and thoughtful. Adequate space is provided for descriptions and explanations that are more complete and understandable than in the typical high school biology textbook.

Origin of Life

Chapter 4 presents 20 pages of thought-provoking material on the origin of life. The chapter begins by describing the big bang theory and the conditions of early Earth. A one-year calendar is used to mark important events during the 4.6 billion year history of the Earth. The calendar notes that the earliest life appeared on April 30 and humans appeared at 10 p.m. on December 31. A small and concise geologic time scale is used here, also.

The hypotheses of Oparin and Haldane, which provide the basis for the heterotroph hypothesis, are explained along with the experiments of Urey and Miller. The authors describe the investigations concerned with the possibility of life on Earth beginning from amino acids brought here by meteorites. Questions about whether the first life was "naked" organic molecules or inorganic crystals that could self-regulate or cell-like structures enclosed within a membrane are discussed. Models concerned with cell formation are described briefly.

The 3.5 billion-year-old fossil-bearing rocks found in Australia are described. The distinctions between prokaryotic and eukaryotic cells and fossils are noted. Lynn Margulis' hypothesis that mitochondria and chloroplasts may have originated as free-living cells and formed close association with anaerobic prokaryotes is included, as is the Gaia Hypotheses which "suggests that Earth, including all of its biotic and abiotic components, may constitute a huge, living, self-regulating system."

Overall, the origin of life is treated in a comprehensive and interesting manner, and the presentation illustrates how questions in science are approached and investigated.

THE NATURE OF SCIENCE

The opening page of the textbook indicates that biology "unites scientific methods with technology" to search for answers to fundamental questions. This textbook does focus on many such questions and, therefore, conforms to this image of biology.

The authors emphasize that in science, "problem solving is based on the interpretation of data, which is information gained through observation, measurement, or experimentation." Overall, the textbook supplies a good description of science and how science answers questions. The development of Darwin's theory of evolution by natural selection and Lamarck's theory that a change in the environment produces a need for change in animals are used to illustrate the methods of science.

The authors indicate that 1) science is based on results of observations and experiments; 2) the results of these observations must be repeatable and verifiable; 3) the findings of science must be refutable; 4) science is based on the assumption that the natural world can be investigated and explained in terms we can understand; and 5) explanations will change or be modified as new knowledge is acquired. Using these criteria, the authors illustrate why creationism is pseudoscience rather than scientific. They also use Galileo's trouble with the church to indicate why science cannot be legislated or dictated.

The authors define a theory as "a model that explains current observations and predicts new observations." Hypotheses are defined as "questions that are testable through experiment or observation." Using the ideas of Darwin and Lamarck, the authors formulate several hypotheses and illustrate how hypotheses are accepted or rejected on the basis of observations and data.

Presentation of Science

In the preface, the authors indicate they were motivated by the assumptions that "an understanding of the nature of science is at least as important as the knowledge that comes from scientific research" and that "science is an interaction of facts and ideas." They conclude that the text should be a "narrative of inquiry," emphasizing "the nature, growth, and function of scientific theories."

Science as inquiry is also part of the BSCS philosophy that shapes this textbook. This philosophy states that "the aim of an inquiry approach is to show some of the conclusions of science within the context in which they arise and are tested." The statement also indicates "scientific knowledge can change."

Overall, the presentation of science in this textbook reflects the aforementioned assumptions and the BSCS philosophy. The 61 laboratory activities are investigative and require a wide range of process skills. Questions at the end of the chapters are divided into categories of reviewing ideas, using concepts, and synthesis. Questions in the last two categories cannot be answered by merely reading the textbook. Concept-mapping activities, which help students organize information and establish relationships between ideas, are used throughout the textbook.

The authors adhere to their assumption that a text should be a "narrative of inquiry." This narrative is best exemplified in the chapter on development where a series of experiments used to test models of development are described.

The authors do not qualify any conclusions or assertions by using terminology such as "scientists believe" and "scientists think." The language used throughout the textbook is direct and conforms to that found in reputable scientific publications.

Other Considerations

Over the past decade, critics have noted the failure of the science curriculum to relate science to human affairs and the lives of students. The BSCS philosophy statement responds to this challenge by identifying science and society as one of the themes of the textbook. Chapter 1 opens with a description of "the new biology" and asserts that "the new biology confronts you with questions and choices people once had never imagined." The book then moves to a discussion of AIDS, the use of human growth hormones, and bioethics.

A feature called "Biological Challenges," is used throughout the textbook to deal with topics such as infertility, eating disorders, and stress management. Another feature, "Focus On," provides a glimpse of topics such as aerobics, diet and cardiovascular disease, osteoporosis, hypertension, AIDS, the greenhouse effect, contraception, diabetes, and cancer. Other topics, such as acid rain, amniocentesis, ultrasound, genetic engineering, drugs, stress, and AIDS are integrated into the text. The appendices include dietary guidelines, fiber values of common foods, and sources, uses, and effects of some psychoactive drugs.

Overall, aspects of the "new biology" are emphasized, but the "old biology" still commands much space. During the 1960s, the BSCS textbooks were viewed as models for biology education and used widely. Evaluations since that time have criticized BSCS for developing textbooks that were too esoteric and divorced from the lives of the students. This edition addresses that shortcoming, but it does not achieve the goal of integrating the theme of science in society thoroughly throughout the textbook.

The authors' statement that this textbook is aimed at providing above-average, motivated students a sophisticated knowledge of biology should be noted by potential users. Because of its emphasis on molecular biology, this textbook is very theoretical and abstract and not appropriate for all students. The abstractness of many of the topics is mitigated somewhat by the use of examples and a considerate writing style.

SUMMARY

Since its initial development in 1961, BSCS Blue Biology has emphasized evolution as a theme in a generally comprehensive and uncompromising manner. This edition is no exception.

Evolution is emphasized in a variety of contexts and is a theme throughout the textbook. The material on evolution is written in a direct, thoughtful, and interesting manner. Also, much of the material concerned with evolution was written in a manner that illustrates how science works to answer questions.

In this textbook, as in previous BSCS Blue textbooks, the laboratory and end-of-chapter activities emphasize science as inquiry. The authors also successfully adhere to their promise to emphasize the nature, growth, and function of scientific theories. Overall, students using this textbook will have ample and continuing opportunity to develop an understanding of the nature of science.

It is unfortunate that the major emphasis on molecular biology limits the use of this textbook, because it represents "good" science and solid biology, is written in an interesting manner, poses good questions, uses engaging laboratory activities, and makes a good start in developing a "new biology."

TITLE: *Biology Today*
AUTHORS: Harvey D. Goodman, Linda E. Graham, Thomas C. Emmel, and Yaakov Shechter
PUBLISHER: Holt, Rinehart and Winston, Inc., 1991 Teachers Edition
REVIEWED BY: Gerald Skoog

GENERAL

This textbook consists of 11 units and 54 chapters. Each chapter opens with an outline, the chapter focus, a "Biology and You" feature and one investigation exercise. The chapters end with a summary, a list of vocabulary words, questions, application/critical thinking activities and a list of additional readings.

There are many illustrations, photographs, and special features in each chapter, and an average of 24.5 vocabulary words per chapter. The greatest number of vocabulary words is in the cell chemistry chapter, and the least is in the chapter on human evolution. Sixteen pages of anatomical illustrations, a 22-page glossary, and information on 27 careers in biology are among the features in the appendix.

An ancillary package accompanies the textbook which includes 54 chapter booklets with suggested daily lesson plans, vocabulary worksheets, reading and comprehension worksheets, science skills worksheets, re-teaching worksheets, extension worksheets, section quizzes, chapter tests, and answer keys.

EVOLUTION

Integration Throughout the Text

Overall, evolution is mentioned in a variety of contexts openly and honestly. However, evolution is not woven throughout the textbook in a comprehensive manner. Material concerned with evolution is confined mainly to Chapters 15 through 17.

Unit 1, which is titled the "Study of Living Things" and describes several characteristics of life, does not mention evolution. In discussing adaptation and variation in Chapter 1, the concept of natural selection is described but not identified as such. In the summary for Unit 1 and in a Chapter 6 description of the cell theory, the text notes that questions concerning how life originated remain unanswered. Chapter 6 has a comparison of prokaryotic and eukaryotic cells, however, their evolutionary relationship was not explored here or elsewhere. Overall, evolution is not integrated into topics where it might logically appear, and the change in the nature of life and the earth are not noted until Unit 4, "History and Diversity of Life," which begins by stating that "[e]vidence shows that life forms on earth have changed over vast amounts of time."

The introduction to Chapter 18, "Diversity a Classification," notes that structural and chemical similarities among organisms "' ow whether organisms are closely or distantly related." Midway through the chapter, the authors indicate that homologous structures might "suggest to the taxonomist that the two animals had a common ancestry." In noting that the number of kingdoms of life varies with the classification system used, the authors imply the five kingdom system is favored over the four kingdom system because it can accommodate fungi. The authors ignore the evolutionary basis and significance of the five kingdom classification system. Overall, the chapter on classification, which is in the evolution unit, does not develop and emphasize the concept that the evolutionary relationships and the ancestral history of a species are an integral part of modern taxonomy. No phylogenetic trees are shown in this or any other chapter to illustrate the evolutionary relationships among specific taxonomic groups. Inasmuch as the textbook is organized phylogenetically, this omission is troubling.

Chapter 20 begins by stating that "bacteria and related microorganisms may have been among the earliest forms of life to appear on earth." There is no additional discussion of this possibility. There is a discussion of the classification of Monera but the evolution of Monera and their relationship to other phyla is ignored.

The evolution of plants receives some emphasis. There is no discussion of the evolution of invertebrates but it is noted that the trochophore larva and "other similarities in the development between mollusks and annelids support the hypotheses that these two groups are closely related." The evolutionary success of insects is noted but not explained.

Chapter 35 opens by declaring that "the 43,000 chordate species are the most recent products of evolution." However, this assertion is not developed other than through the presence of a chart of the geologic time scale that shows the history of the vertebrates since the Paleozoic Era. Brief notes about the evolutionary history of fish, amphibians, birds, and mammals appear in their respective chapters. Four pages were devoted to the evolutionary history of reptiles, with most of the emphasis on dinosaurs.

The author's note in Chapter 51 that "the evolutionary process has shaped ecosystems so that in each ecosystem organisms constantly interact with one another." Competition, predation, symbiosis, and biological rhythms are described as biotic relationships, but no aspect of evolutionary theory is a part of the description.

Evidence for Evolution

Fossils, homologous and vestigial structures, embryological development, and biochemistry are presented as evidence of evolution in a standard, five-page description. The section opens with the assertion that "[o]rganisms have changed dramatically since they appeared on Earth about 3.5 billion years ago." Types of fossil evidence are described and radioactive dating is explained. A brief description of the geologic time scale and the history of life on earth is given. The authors conclude that fossils have "revealed many changes in earth during its long history" and have "revealed tremendous changes in organisms." The geologic time scale used in the 1989 edition is modified in this edition to include the appearance of early hominids and the presence of apes as significant events during the Pliocene Epoch.

Biogeography is not cited as evidence of how fossils are used to construct lines of d· · scent and relationships. The "Thinking About Biology" feature gives a brief description of how comparative biochemistry is used to ascertain relationships. There is no discussion of the completeness of the the fossil record, the natural destruction of fossils, or the probability of an organism being fossilized. A description of the asteroid extinction theory is a special feature at the end of the chapter on classification.

Mechanisms of Evolution

The section on mechanisms of evolution begins by defining species and populations. Evolution is defined as occurring "when there is a change in the genetic make-up of a population." The Hardy-Weinberg principle and genetic equilibrium are defined and described. Natural selection, migration, genetic drift, isolation, and mutation are identified as factors that can change the genetic equilibrium in a population. Non-random mating is not included as one of these factors. Three types of natural selection -- stabilizing, disruptive, and directional-- are explained. The emphasis in this section is on changes in genetic equilibrium and the processes that can upset a population's genetic equilibrium. Speciation is given minor treatment in a description of divergent evolution. Adaptive radiation and convergent evolution are in a chapter-ending section. Microevolution is defined as "slow, gradual change" and macroevolution as change "on a grand scale" in a special feature titled "Evolutionary Theory Today," which includes a brief description of punctuated equilibrium.

History of Evolutionary Thought

Lamarck's theory, along with the standard Lamarckian explanation of how giraffes acquired long necks, is presented in less than a page. Darwin's *Origin of Species* is heralded as a "landmark work" that "presented evidence that demonstrated all living things on Earth evolved from other living things." In describing the voyage of the *Beagle*, the authors assert that as the voyage began "Darwin did not accept the ideas that species change," believing that the earth was 6,000 years old and that organisms were specially designed and had not changed. This is one of the few high school textbooks that accurately notes that Darwin left on his voyage as a creationist and returned "convinced that all living things arose by evolution."

Darwin's theory of natural selection is described in a standard and concise manner and labeled "the cornerstone of modern evolutionary thought." Weismann's work, which is not described, is credited with showing that acquired traits cannot be passed to offspring. As in most textbooks, there is a discussion of Darwin's study of 13 species of finches on the Galapagos Islands. According to some historians of science, Darwin did not study or collect the finches during his stay at the islands. He did use finches that were collected there by others in his later studies in London. The separation and brief treatment of the theory of punctuated equilibrium weakens the treatment of evolution and its historical development in biological thought.

Human Evolution

In the opening paragraph of the chapter on human evolution, the authors state that the ancestors of humans "branched off from the ancestors of living chimpanzees and gorillas." However, this idea was not developed. *Australopithecus*, *Homo habilis*, and *Homo erectus* are described. The debate about whether *A. afarensis* is the earliest ancestor of human beings is discussed very briefly. *H. habilis* is given a three-paragraph description but its place in the ancestry of modern humans is not discussed. However, an illustration shows three of the possible lines of human evolution.

The authors state that "most scientists consider Neanderthals to be members of our species" and that they probably disappeared as a result of early competition with the early *Homo sapiens sapiens* known as the Cro-Magnons. The term cultural evolution is not used but Neanderthals were identified as "more culturally advanced than their predecessors" and aspects of their culture are described briefly. A brief paragraph also highlights the culture of the Cro-Magnons.

The final section of the chapter states that about 15,000 years ago humans switched from predominantly hunting and gathering to agriculture as a result of global warming and a reduced population of large animals. The agricultural revolution was accompanied by social changes and a steady increase in population. These changes are re-emphasized in Chapter 53 in a section on human population.

There is no complete discussion of the adaptive radiation of humans and Africa as the probable site of human origin. There is no explanation of how the structure of mitochondrial DNA has been used to trace back the evolution of humans to a beginning in Africa.

Chapter 40, titled "Overview of Human Biology," notes that humans share many physical characteristics with other primates "because humans and other primates developed from a common ancestor." After describing primate traits, the authors indicate that "the earliest humans showed so many ape-like features that scientists sometimes have difficulty telling whether fossil bones are those of an ape or a human" and that "as evolution continued," humans became "more distinctive."

Origin of Life

The unit on evolution begins with a two-page description of the big-bang theory, Oparin's and Haldane's hypotheses concerning the origin of life, and Miller's and Urey's experiments. The authors indicate that the first cells "probably resembled anaerobic bacteria" and about three billion years ago cells capable of photosynthesis developed. The oxygen produced by these organisms "paved the way for more complex forms." The language in this section is direct, reporting the universe and the earth as 15 billion and 4.6 billion years old, respectively.

A four-page description of the classical experiments concerned with abiogenesis in Chapter 2 is used to illustrate the scientific method. The section concludes that "some scientists have hypothesized that the first cells arose from nonliving materials."

THE NATURE OF SCIENCE

Methods of Science

The authors define the goal of science "to establish principles and thereby acquire knowledge about the natural world." The scientific method is defined as a "logical, organized method" used to establish these principles. The authors indicate that the scientific method is made up of different procedures performed in varying order but all draw on the following steps: defining the problem, collecting background information, formulating and testing hypotheses, making and recording observations, and drawing conclusions.

An hypothesis is defined as a statement that can be tested and may be based on information available or may be an educated guess. When an hypothesis explains "how an event occurs, it becomes a scientific principle or law" whereas "when an hypotheses explains why events occur, it becomes a theory." In the glossary, a theory is defined as "a scientific explanation of known facts." The authors indicate that scientific theories are open to revision and replacement and cannot be considered final. The authors distinguish between independent and dependent variables and experimental and control groups. The authors use the traditional experiments of Redi and others concerned with abiogenesis to illustrate the scientific method. A special feature titled "Fake Science" describes pseudoscience and notes that it has "no peer review, demand for accuracy, or scrutiny of the methods used to obtain results" and relies "on opinion, testimony that cannot be verified, and ideas that have not been tested using a scientific method."

Overall, Chapter 2 provides a good description of science and how science works to answer questions. However, when this textbook is revised the "hypothesis as a hunch" statement should be dropped and the role of intuition in science should be acknowledged.

Presentation of Science

The presentation of scientific knowledge rather than scientific process or methodology, dominates in this textbook. However, the 53 laboratory investigations are not the traditional laboratory verification exercises that characterize most biology curricula. Most of the laboratory activities are investigative. Flowers are the only specimens dissected. The prelab section of each laboratory generally requires students to gather or organize information. The analysis phase of most laboratory activities requires the students to use many different process skills.

There are at least 30 questions throughout each chapter. Many of the questions are what, how, and why questions that can be answered directly by reading the textbook. However, each unit ends with several synthesis questions that demand much student understanding and thought.

The authors use a sprinkling of "scientists believe" and "scientists think" statements to qualify some assertions or conclusions. However, the authors are generally direct and tend to avoid the qualifying statements that dilute a straight forward presentation of science.

Other Considerations

The textbook gives no emphasis to creationist tenets or the so-called "theory of intelligent design."

This textbook partially overcomes the criticism that the science curriculum fails to relate science to human affairs and the lives of students. The text contains a "Biotech" feature in each unit, a "Biology and You" feature in each chapter, and 77 "Thinking About Biology" features. The topics in these features include DNA fingerprints, genetic counseling, the Human Genome Project, eating disorders, Alzheimer's disease, artificial body parts, and the garbage heap. Information and issues concerned with AIDS are presented in several different chapters. Even though the authors have used several features in attempt to relate biology to the lives of students, classical biology dominates the 990 pages.

The textbook is typical in that it starts with molecular and cellular biology, moves to the study of genetics and evolution in Chapters 10 through 17, parades through the phyla, and at Chapter 40 and page 644 begins the study of human biology. The last unit pages focuses on ecology. Student interest, motivation, and knowledge might increase significantly if biology textbooks and individual chapters started with more familiar and concrete areas of student interest and moved to more abstract and theoretical areas. As noted in the teacher's guide, the units and chapters of this textbook do not need to be studied in sequence. However, it would be difficult to realign the chapters and redefine the content into a sequence that builds from the concrete and familiar to the abstract and theoretical.

SUMMARY

This textbook is a revision of the 1989 edition of *Biology* by Harcourt Brace Jovanovich, Inc. and overall is an improvement.

Unfortunately, this 990 page textbook and its accompanying bulky set of ancillary materials represents an effort to satisfy all state textbook committee requirements and those of individual teachers nationwide. As a result there is something for everyone, but no core of biology that results from a serious deliberation of the question, "[w]hat knowledge of biology is most important for students who will spend most of their lives in the twenty-first century?"

The high density of topics often results in shallow coverage and pages laden with too many ideas and concepts. For example, the outline of topics concerned with evolution in this textbook is comprehensive, but sufficient space is not available to allow for a presentation that uses many examples and provides a complete explanation.

The emphasis on evolution primarily was confined to three chapters. The material in these three chapters was presented in a honest and correct manner. The allocation of more space to the three chapters and a more thorough integration of evolution throughout the textbook would increase student opportunity to develop an understanding of evolution and its role in shaping the natural world.

In general, the expository style of writing, length of the textbook, heavy emphasis on vocabulary, and high density of topics provided emphasize science as knowledge and a body of conclusions more than science as a process and a way of knowing. This emphasis is countered slightly by investigative laboratory exercises and some thought-provoking questions.

TITLE: *Modern Biology*
AUTHOR: Albert Towle
PUBLISHER: Holt, Rinehart and Winston, Inc., 1991 Teachers Editions
REVIEWED BY: Gerald Skoog

GENERAL

This textbook consists of 53 chapters ranging in length from 10 to 22 pages. Each chapter includes a laboratory activity, vocabulary words, questions, and extension activities. There are many illustrations, photographs, and special features. In addition, the text is filled with vocabulary words, averaging 29.6 per chapter. The chapters on the human body have the most vocabulary and those on evolution the least.

Because of the market for comprehensive textbooks that use many illustrations, include laboratory and other student activities, and have special features that emphasize careers and technological breakthroughs, the amount of space for any given topic is limited. For example, the final chapter, "Protecting Life," lists 30 vocabulary words that include acid rain, biodegradable, endangered species, hazardous wastes, and ozone. The chapter uses one page each for a chapter opener, a biotechnology feature, and a laboratory activity. Two sets of review questions, a photograph, and an illustration reduce the available space for text even further. As a result, acid rain is allocated six lines and threatened and endangered species are explained in four lines. This same editorial policy and practice has resulted in a five-chapter unit on evolution that includes a comprehensive outline but little space to develop the topic.

EVOLUTION

Integration Throughout the Text

Despite the limitations of space, this edition gives more coverage to evolution than its predecessors published in the 1970s and early 1980s. The first two paragraphs of the textbook depict an evolutionary view of the world. The first line of the textbook states that "[l]ife arose on earth over 3.5 billion years ago." Evolution is defined on the second page of Chapter 1 and depicted as "the unifying theme of biology." A phylogenetic tree of birds also is illustrated on this page and described as "the probable evolutionary history of a group of organisms." Later, natural selection, as conceptualized by Darwin, also is heralded as the unifying theory for all biology. Evolution is identified as one of the seven themes that unify biology and recurs throughout the textbook. Such claims have been common and unkept in many earlier textbooks. However, in this edition, evolution clearly is threaded throughout much of the textbook as a theme and is dealt with in various contexts.

Invertebrate and vertebrate evolution are dealt with in a more comprehensive and honest manner than done in recent editions of this and other textbooks. Chapter 35 is a short chapter concerned with the evolutionary trends in invertebrates. This chapter is preceded by some of the evidence of invertebrate evolution as invertebrate phyla are described. The study of the classes of vertebrates concludes with a chapter on the evolutionary trends in vertebrates. This chapter focuses on the origin and phylogeny, the development and morphology of various systems, and the behavior of vertebrates. Each of the chapters concerned with the five classes of vertebrates contain a phylogenetic tree illustrating the evolutionary history of the specific class. The language accompanying these illustrations is direct. For example, the author states that "[t]he phylogenetic tree of reptiles shows animals with a wide array of adaptations diverging from common ancestors" and that "[t]he diversity of mammals is a result of evolution since the beginning of the Mesozoic." The study of each vertebrate class begins with a section about its evolution and classification. For example, there is a thoughtful, one-page description about the origin and evolution of mammals. A more lengthy discussion of the evolution of the reptiles includes a description of the asteroid extinction theory.

The textbook also treats briefly the evolution and classification of viruses, protozoa, fungi, and plants. There is a chapter on plant evolution and classification. The chapter on classification, which is in the evolution unit, emphasizes that evolutionary relationships and the ancestral history of a species is very much a part of modern taxonomy. However, the authors ignore the evolutionary basis and significance of the five kingdom classification system.

Evidence for Evolution

Fossils, common ancestry of 23 honeycreeper species, biochemistry, and embryological development are given as evidence of evolution in a standard and concise five-page section. Biogeography, or the distribution of organisms, is not cited as evidence of evolution. There is no explanation of how fossils are used to construct lines of descent and relationships. The author fails to describe the completeness of the fossil record, the natural destruction of fossils, and the probability of an organism being fossilized. The asteroid extinction theory, which was presented briefly in the chapter on reptiles, was not noted in this chapter.

The presence in this section of phrases such as "strongly suggest," "could be interpreted," "probably," and "apparently" betray the confidence that scientists have in the evidence that supports evolutionary theory. For example, the author cautiously states that the fossil record "could be interpreted to mean that species evolved from more direct ancient organisms." Whereas a college textbook refers to the fossil evidence left by 20 genera of the horse family as "unusually complete" and "powerful evidence of an agelong evolutionary continuum," this textbook asserts that "[t]he similarities and the differences between the feet of horses from different epochs strongly suggest that horses changed over time." However, the tone is less cautious elsewhere in the textbook. For example, the author asserts that "[t]he evolution of the vertebrates has led to the seven classes that exist today" and "[t]he fossil record indicates that various fishes were the first vertebrates on earth."

Mechanisms of Evolution

The coverage of the mechanisms that result in speciation and therefore evolution is direct and concise. The chapter on speciation begins by defining species and populations and by comparing the morphological and biological concepts of species. Genetic equilibrium and the Hardy-Weinberg principle are defined. Variation within a population and gene pools are discussed. Mutation, migration, genetic drift and natural selection are described as processes that cause changes in the gene pool. Non-random mating is not included as a process that causes changes in a gene pool. The four types of natural selection -- stabilizing, directional, disruptive, and sexual -- are described. The role of geographic and reproductive isolation in speciation is described. The rate of speciation and the theory of punctuated equilibrium are explained in about two-thirds of a page. The chapter on speciation ends with a page on extinction. Natural selection, as conceived by Darwin, was described in one page in the preceding chapter, as was adaptive radiation and divergent and convergent evolution.

History of Evolutionary Thought

A compact, five-page section describes and discredits Lamarckian evolution, summarizes Darwin's life and his voyage on the *Beagle*, explains natural selection as conceptualized by Darwin, and describes the importance and impact of Darwin's book *The Origin of Species*. A special section on England's peppered moths is included. The obligatory illustration of how Darwin and Lamarck explain the giraffe's long neck is missing. This section could be improved by a discussion of how Lamarck's hypothesis can be disproved and a more complete discussion of the concept of fitness and the role of variation in natural selection. A later chapter presents a brief description of the theory of punctuated equilibrium but does not explain it as a recent theory.

Human Evolution

Humans are classified with monkeys and apes as anthropoids. Comparisons between the characteristics of humans and other anthropoids are made. However, there is no explanation of the evolutionary relationships between humans and other anthropoids. Modern humans and earlier human forms are not discussed. There is no discussion of the adaptive radiation of humans and Africa as the probable site of human origins, or of how the structure of mitochondrial DNA has been used to trace the evolution of humans to a beginning in Africa. Other than a brief paragraph on Cro-Magnon culture and two lines about the life of Neanderthals, there is no emphasis on cultural evolution.

Origin of Life

The chapters on evolution are preceded by a chapter on the origin of life which begins by describing early experiments concerned with spontaneous generation and provides brief sections on the formation of the earth, appearance of life on earth, the work of Oparin, Miller, and Urey, the formation of organic compounds, the evolution of growth, metabolism, and reproduction, and the evolution of prokaryotes and eukaryotes. This chapter qualifies many statements with "probably" and "evidence suggests, " but overall it is quite straightforward. It clearly indicates that earth is about 4.6 billion years of age and that life appeared sometime between 4.6 billion and 3.5 billion years ago and has continued to evolve.

NATURE OF SCIENCE

Methods of Science

Chapter 2 describes how the scientific processes of observing and collecting data, measuring, organizing data, classifying, hypothesizing, predicting, experimenting, analyzing data, inferring, modeling, and communicating are used to obtain knowledge about nature. A description is provided of how scientists use these processes to answer the question "[w]hat species of birds live in a particular area of the South American rain forest?" The author emphasizes that these processes are used in different combinations and that there is no single method for asking and seeking answers to questions in science.

A theory is defined as "the most probable explanation for a set of data based on the best available evidence." The author notes that laws and theories may be modified or discarded and that the tentative nature of science "leads scientists to constantly weigh evidence, examine inferences, and modify hypotheses." However, little of this aspect of scientific inquiry is found in this textbook. For example, the differences between those who trace human ancestry with fossils and those who use biochemical analysis, and the differences concerned with the rate and tempo of evolution could be used to show how scientists change the ideas of their colleagues in a healthy, but sometimes very competitive, process.

The author avoids using "scientists believe" or "scientists think" statements to qualify conclusions that could be controversial. Generally the author is direct. For example, he states that evidence "indicates that birds evolved from a group of reptiles called therapsids." He also asserts that "200 million years ago the continents were joined as a single landmass" and later "the continents drifted apart." The use of such direct language should be the norm, but many authors during the past decade have qualified these and similar statements.

The author uses infer, inferences, and inferring regularly. For example, he states that "biologists infer that reptiles arose from a group of ancestral reptiles called cotylosaurs." In contrast, a college textbook states directly that "cotylosaurs appeared about 310 million years ago" and later "radiated into a host of reptilian groups that inhabited the shifting land masses."

The author defines inferring as "the process of drawing conclusions on the basis of facts or premises instead of direct perception." He notes that some inferences can be theoretically tested, whereas others could not. Inferring was listed as a process skill in at least 30 of 53 laboratory investigations. A casual review of several investigations failed to find questions or situations that required students to develop inferences as defined by the author.

Presentation of Science

This textbook clearly emphasizes knowledge to a much greater extent than process or methodological aspects of science. Few of the 53 laboratory activities require students to answer any questions by experimenting and collecting, organizing, and interpreting data. What, how, why, list, and describe are the answers required by many of the multitude of questions in the textbook. There is no evidence that the science, as well as the scientific enterprise, is a process of constructing meaning about the natural world and not simply a process of accruing information.

Other Considerations

The textbook gives no emphasis to creationist tenets or the so-called "theory of intelligent design."

This textbook does not help overcome the frequent criticism that the science curriculum fails to relate science to human affairs and the lives of students. Although the book contains a listing of acid rain, AIDS, bioethics, famines, fetal alcohol syndrome, gene cloning, greenhouse effect, hazardous wastes, and other science-related societal problems in the index, it does not deal with any of these and other science-related issues in detail.

Modern Biology and its predecessors that date back to 1921 have emphasized the phylogenetic approach and classical biology. As a result of this emphasis and its continued acceptance by teachers, the anatomy of worms, crayfish, grasshoppers, starfish, fish, frogs, birds, and other organisims receive much emphasis. It is important to note that this emphasis has decreased in this edition. However, there is still more space allocated to the fins of fish or the digestive system of the frogs than there is to acid rain or the effects of pesticides on natural systems. Similarly, Mendel's classical experiments with peas receive more space than genetic engineering. Although contraceptives are not discussed or even listed in the index, the reproductive cycle of flukes is included.

The textbook is typical in that is starts with molecular and cellular biology, moves to the study of genetics and evolution, parades through the phyla, and at Chapter 42 and page 634 arrives at the study of human biology. Ecology is covered in the final unit and last 60 pages. Student interest, motivation, and knowledge might increase significantly if biology textbooks and individual chapters started with more familiar and concrete areas of study and moved to more abstract and theoretical areas. Obviously, the units and chapters of this textbook do not need to be studied in sequence. However, it would be difficult to realign the chapters and redefine the content into a sequence that builds from the concrete and familiar to the abstract and theoretical.

SUMMARY

This textbook gives unprecedented emphasis to evolution. Despite some tentative language, shallow treatment of some topics, and the omission of other topics, evolution is treated in a comprehensive and honest manner. Evolution is presented thematically, beginning in Chapter 1 and carried throughout the book. Because *Modern Biology* is one of the most widely used textbooks in the nation, it influences the marketing and development plans of other publishers. Thus, it is significant that this textbook has departed from the timid treatment of evolution that characterized it in the past.

Unfortunately, the textbook tries to satisfy all state textbook committee requirements and those of individual teachers nationwide. As a result, it fails to focus on a core of biology that reflects current thinking about what students need to know to understand the natural world.

TITLE: *Biological Science: An Ecological Approach*
AUTHORS: Biological Sciences Curriculum Study
PUBLISHER: Kendall/Hunt Publishing Co., 1987
REVIEWED BY: Wayne A. Moyer

The text is divided into five sections: "The World of Life: The Biosphere"; "Continuity in the Biosphere"; "Diversity and Adaptation in the Biosphere"; "Functioning Organisms in the Biosphere"; and "Patterns in the Biosphere."

The scheme of the book is evidenced by the section titles. Opening with a naive view of ecological relationships, the authors proceed to introduce concepts of population, community, ecosystem, and energy flow. But to comprehend these global ideas, the reader is led through a discussion of the underlying biology: cells, heredity, development and evolution. The text returns to the organismic level with an extensive march through the phyla lasting 222 pages, which begins with pre-biotic conditions on earth and concludes with eukaryotic organisms. The study of the organism is concluded with a review of flowering plants, a subject often neglected despite our national preoccupation with lawns and gardens. The final section returns the reader to the level of ecosystems, with chapters on the history of earth-life, human evolution, biomes, aquatic ecosystems and examination of human-shaped ecosystems.

EVOLUTION

Integration Throughout the Text

The references to "evolution" in the index cite 78 pages, scattered throughout the text. The first reference is to a 40 page chapter titled, "Continuity Through Evolution," wherein the authors present several hypotheses explaining how evolution might occur, including Darwin's theory of natural selection. In the following chapters on eukaryotes is a diagram depicting possible evolution of eukaryotic cells. The chapter on higher plants is organized around the evolution of their structure and reproduction. While the chapter on animals contains fewer references to evolution, there is a chart depicting evolution of animals. (In a subsequent chapter, reference is made to modern human diets versus that prevailing during most of our evolutionary history.) Section five contains a number of chapters on topics that include selection and survival, ecosystems of the past as deduced from fossil remains, and human evolution.

Evidence for Evolution

If an hypothesis of evolution is true, then one should find evidences for biological change in a number of places. For example, one should find evidence that animals and plants from the remote past were radically different from those alive today or in the recent past. The authors provide ample evidence for this generalization in a chapter on "Ecosystems of the Past." The nature of fossils, how they are studied, and the nature of early life forms are all presented. One should also find evidence of evolutionary relationships in the distribution of plants and animals in the world. A two-page chart in this same chapter relates evolutionary events to the movement of continents. These ideas are elaborated in subsequent chapters on world biomes.

Evidence for evolutionary change is also to be found in anatomy and biochemistry of modern organisms. These concepts are covered in a chapter on classification, which establishes evolution as the basis for biological classification. The authors note, "Similarities of structure that indicate related ancestry are especially important in classification."Biochemical homologies are described, including the astounding match between human and chimpanzee DNA. A chart in the evolution chapter demonstrates the similarity between early stages of embryonic development of vertebrates.

Mechanisms of Evolution

The chapter on "Continuity Through Evolution" begins with the basic question; how can we account for the enormous variety of living things, both now and in the past? This is the question Darwin addressed in "The Origin of Species" and it remains the proper place for a modern textbook to begin. Several examples of diversity are presented, followed by a brief history of the concept of change through time, with examples drawn from animal breeding. But the authors then move directly to natural selection as the explanation of evolutionary change. This, I feel, is a pedagogic error, as students first need to confront the overwhelming evidence that species have changed through time, that species are distributed throughout the biosphere in particular patterns, and that classification is possible only because of phylogeny.

Nevertheless, this chapter is well written, and includes an account of the *Beagle* voyage, Lamarck's hypothesis of use and disuse of organs, and the modern synthesis. Natural selection is illustrated through reference to the peppered moth of England, while mutations are shown to be the source of variation. The roles of population size in establishing an incipient species and of isolation in fixing a new type are discussed. Punctuated equilibrium is discussed as an alternative to gradualism in explaining speciation.

In a previous chapter, the authors do consider the question: what is a species? Understanding of the species concept is essential to understanding classification, evolutionary theory and population biology. For once, binomial nomenclature is correctly explained, with a correct distinction made between genus and trivial names in the two-part species name.

Definitions

Evolution is correctly defined in the glossary as "change through time that results from natural selection acting on genetic variations present among individuals of a species." Natural selection is defined as "the tendency of members of a population with the most successful adaptations to their environment to be the surviving members and parents of the next generation."

History of Evolutionary Thought

The chapter on evolution does a good job of reviewing the history of ideas about evolution and how species change through time. Lamarck is given fair treatment, and not treated like a buffoon.

Human Evolution

This important topic is treated in 18 pages of a chapter on "Ecosystems of the Past." Primate brain evolution is treated in a student investigation. The nature of primates, early hominoids, and description of the genus Homo, follow. A chart depicts one hypothesized path of human evolution, while the text acknowledges that this area of knowledge is changing every year. A second student investigation compares the skeletons of a human and a four-footed animal. Cultural evolution is mentioned and examples of stone tools made by *H. erectus* are depicted.

Origin of Life

If all life comes only from previous life, how did it all begin? This essential question is dealt with in the chapter on biological classification. Beginning with the statement, "All species may have come from a single ancestral species," the authors move to consideration of hypotheses on how life might have started. The Stanley Miller apparatus is depicted and described and recent reports of RNA acting as an enzyme are cited. The early history of the earth based on astronomical and geological data is presented. The chapter concludes with the heterotroph hypothesis.

THE NATURE OF SCIENCE

Methods of Science

The hypothetical-deductive method of scientific inquiry is introduced with the question: "[w]hat attracts bees to the bright red flowers in the field?" An hypothesis is suggested: "[b]ees are attracted to this kind of flower because of its red color. This leads to an "if...then" proposition; if the red color is attracting bees, then an artificial red flower should also attract bees. Here is where the authors and I part company. Rather than presenting one hypothesis, I would rather ask the students to propose a variety of alternative hypotheses, followed by a series of experiments designed to distinguish between them.

While this discussion of scientific inquiry is better than most, in my opinion, the authors fail to apply the method to any of the many laboratory investigations. Each investigation begins with a short introduction that raises a general question such as, "[t]o what extent is the phenotype of an organism the result of its genotype? And, to what extent is the phenotype influenced by its environment?" Instead of inviting students to consider these vital questions and possible ways of answering them, the authors provide a list of materials, a cookbook procedure and a set of discussion questions. The authors would do well to return to the philosophy of the old laboratory blocks and the very effective but short-lived second-level biology program.

Presentation of Science

Science is presented in this textbook as an exciting but unfinished story. The work of scientists is accurately described in full-page vignettes scattered throughout the text. For example, Barbara Winternitz is described as an ecologist teaching at Colorado College who also works with people to preserve habitats in the face of human development.

Terminology of Science

Theory is accurately defined in the glossary both in its general sense (a conjecture) and in its scientific sense (an hypothesis that organizes knowledge in a field). Hypothesis is correctly defined as an explanation for an observation. In general, technical terms are used only when everyday language is inadequate. Even then, the terms are used in more than one place.

Characteristics of Science

Science is presented in this textbook as a complex body of constructed knowledge that is being increased daily. What is now known is identified along with what is not known. For example, the chapter on development ends with a consideration of what causes cancer and this statement: "[c]learly, the solution to the riddle of cancer depends on understanding normal cell division and its role in development."

Other Considerations

This text does far better than most biology textbooks in dealing with issues emerging from human activities. The final two chapters treat the human-shaped environment and humankind in the future. The authors pull no punches and make it clear that humans are in control of the planet and that their future activities will determine its fate. Population growth, genetic engineering, and global warming are all considered as issues on which citizens should have informed opinions. We applaud this straightforward approach, but undoubtedly it will cause some to criticize this textbook because they believe that ecology is not important in an expanding economy, or even because the text contains drawings of human reproductive organs. In our opinion, the discussion of social and human issues is an asset.

SUMMARY

This textbook offers an exhaustive treatment of both ecology and biology. Its size is overwhelming and some pruning would have helped. For example, there is a very extensive review of phylogeny that many teachers -- because of their own college training -- will be sorely tempted to extend even further, leaving little time for teaching the ecological concepts that are the heart of the textbook. The same is true for the three chapters dealing with human biology. Since so much of this ground is also plowed in life science courses commonly taught in grade seven, the wise teacher will move quickly through these chapters.

TITLE: *Biology: The Dynamics of Life*
AUTHORS: Alton L. Biggs, Donald S. Emmeluth, Chris L. Gentry, Rachel I. Hays, Linda Lundgren, and Francesca Mollura
PUBLISHER: Merrill Publishing Company, 1991
REVIEWED BY: Eugenie C. Scott

Merrill's *Biology: The Dynamics of Life* takes a "phylogenetic" approach. This term of art is often used by teachers and publishers to describe a book that progresses through all the major taxa, but ususally there is no "phylogeny" (in the sense of evolutionary history) at all. Commonly, there is just a "forced march through the phyla," in Wayne Moyer's terms. In this textbook, however, there is actual phylogeny involved. The students cover microbiology, plants, invertebrates, and vertebrates, but they also receive information on the evolution of these groups. In most books, taxa are presented as separate entities, unconnected to one another and unrelated to time. In this book, right from the beginning, major taxa are presented as being related to one another and having changed through time. Finally, a *truly* "phylogenetic" book.

There are 36 chapters organized into nine units: "Life," "Cells, "Genetics and Evolution," "Microbiology," "Plants," "Invertebrates," "Vertebrates," "Human Biology," and "Ecology." Each unit is preceded by a bold painting accompanied by a poem or other literary selection from well-known figures like Emerson, Steinbeck, Thurber or Rachael Carson, and the Blackfoot Indian chief, Crowfoot. The passages encourage students to reflect and contemplate subjective elements of the topics to be discussed, which is a nice touch.

Each chapter is introduced by a paragraph that ties the material to come to something familiar to the student, and ends with a chapter review. There are 36 laboratory exercises scattered throughout. Controversial issues including pesticide usage, anorexia, endangered species, recombinant DNA and others are presented in nine "Developing a Viewpoint" essays that occur throughout the book. Biotechnology and career choice essays, as well as critical thinking exercises on a variety of biological puzzles, also appear within chapters. On the whole, these are well chosen, with plenty of variety to interest students.

The authors claim to have produced a more "manageable" text. The goal was to produce a book of "major concepts and principles of biology that can be comfortably absorbed in a single school year," and they have succeeded. The number of bold-faced vocabulary words is significantly more manageable than most other books, but this "less is just right" approach still has not made available enough space to discuss controversies or alternate scientific positions.

EVOLUTION

Integration Throughout the Text

Three themes run throughout this book: evolution, ecology, and homeostasis. The thematic approach is commendable.

However, some logical opportunities for incorporating evolution into the book have been passed by. "Phylogeny of Mammals" has a wonderful diagram showing the placement of different orders of mammals in time, but the text ignores the evolutionary relationships among them. The introductory paragraph to the section states that mammals are classified according to methods of reproduction, habits and locomotor adaptations -- but nothing about evolutionary relationships.

Later in the chapter, after touring all the mammalian orders, a section called "Origins" appears. "Origins" is not a scientific subfield and it is odd to see it as a chapter title in a book that treats evolution properly. The Origins section is only a couple of paragraphs long and merely introduces the mammal-like reptiles. It does not relate different orders to one another or go into depth other than to st. e that monotremes, marsupials, and placentals come from therapsids. Because of the interest students have in mammals, it seems that more could have been done to relate the orders to one another. The closest relative to dogs, for example, are bears.

The "Animal Behavior" chapter takes an opportunity to remind us of evolution, by stating that "[b]ehavior also can be used to show the evolutionary relatedness of species."

The diagrams showing the relationships of major phyla to one another, and the temporal associations, are superb.

Chapter 2, "Diverstiy," introduces the evolution theme and covers species definitions, taxonomic nomenclature, and makes a quick skip through the five kingdoms. The evolutionary relationships among organisms, rather than "similarity," is correctly stated as the basis for classification. There are also brief discussions of the origin of life and the fossil record.

Homology is covered in the evolution chapter, and is linked with classification. The definition of homology ("structures that are similar and are derived from the same body parts") is not inaccurate but it is incomplete. This definition stresses the embryological origin of homologous structures, rather than evolutionary relationships, the ultimate cause. The example used is homology in the skeleton of the forelimb of three pinnipeds (walrus, seal, and sea lion), and indeed, these species share common ancestry. But perhaps because they are obviously so closely related, students may not understand the true significance of homology to evolution.

Evidence for Evolution

Chapter 11, "The History of Life", presents the origin of life, the origin of prokaryotes and eukaryotes, and then jumps to human evolution, which skips a lot in between. But the evolution of all the intermediate organisms is handled in their respective chapters. Evolution is correctly considered a normal part of the description of each group of organisms. Connections within some groups are presented, such as among the classes of echinoderms, mammals, and reptiles. Relationships between groups are also presented, for example arthropods are descended from annelids, and amphibians from lobe-finned fish. Birds and reptiles are discussed together, which is appropriate, as they are very closely related. Other positive features in each chapter on the major phyla are the gorgeous illustrations showing the temporal relationship of major groups within the phyla.

There are occasional errors, however. Birds are descended from small carnivorous dinosaurs, rather than thecodonts, as stated. Primates have rotating forearms, not rotating "forelimbs." *Australopithecus africanus*, discovered by Dart, was not dated by radioactive dating methods; these methods had not been developed at the time of the discovery of this fossil.

Chapter 10 presents "Evidence of Evolution" as its first subsection. Fossils are presented as evidence that evolution has occurred, a point that needs to be made, but fossils also can illuminate the relationship *between* organisms such as reptiles and birds, an idea that is not developed. The section on fossils reminds students that fossils lower in the geological column are older than those higher in the column. It then points out that fossils lower in the column are less complex than fossils found above them. Thus evolution (change through time) has taken place. Most books do not present this basic proof of evolution as clearly and simply.

Embryology and vestigial structures are only briefly mentioned. The definition of a vestigial structure is soundly evolutionary, however: "the remnant of a structure that was once functional in an ancestor." DNA and RNA comparisons across organisms get a somewhat longer treatment, but it is still brief. The book underscores that biochemical evolution reinforces the basic idea of homology. Just as anatomical similarities are greater among more closely related forms, organisms that share a recent common ancestor are more similar biochemically than those more distantly related.

Biogeography is not discussed as evidence of evolution.

Mechanisms of Evolution

Although evolution is treated honestly and without compromises, the book does fail in its presentation of some important concepts and principles of evolution.

The glossary definition of natural selection is cumbersome: "The theory that a mechanism for change in populations occurs when organisms with characteristics most favorable for survival in a particular environment are able to pass these traits on to offspring." It neglects to say that the result of natural selection is the *differential* reproduction of "organisms with characteristics most favorable for survival in a particular environment." Disadvantageous traits get passed on, too, only not in as high numbers. The discussion of natural selection in the body of the text is abbreviated, with more time spent on Lamarck's giraffes than the voyage of the *Beagle*.

In the review section of Chapter 10, students are asked to use the concept of natural selection to predict what would happen to the relative frequencies of light and dark moths in England after air pollution controls. A note to the teacher explains "that the light-colored peppered moths will be in greater proportion than [sic] the dark-colored peppered moths" without mentioning that this indeed did happen in England during the late 1970s and early 1980s. This is not a hypothetical situation, but a real one. Did the authors know this?

The text tackles stabilizing, directional, and disruptive selection as well. Stabilizing selection is handled accurately in the textbook, but the drawing supposedly illustrating how medium-length grass stems are selected doesn't communicate the idea of the relative frequency of the lengths of stems. In fact, the illustrations for these three types of natural selection, while pretty, are likely to detract from the text itself.

Punctuated equilibria is presented incompletely and inaccurately. A passage claims that "a new species is formed" in "a span of 1000 years or less," which is wrong. From this definition, it is possible for a student to conclude that the entire species evolves into a new species. There is no indication to the student that punctuated equilibrium deals with branching evolution (a species splitting off from a parent species). Second, although proponents of punctuated equilibria claim that evolution occurs rapidly, no one is talking about a period as short as 1000 years.

Evolution is presented as a change in gene frequencies through time, and as a change in genetic equilibrium. Processes of evolution are presented as mechanisms that disrupt equilibrium. So far, so good. The textbook slows down a bit, though, when dealing with specifics. For example, mutation is a disrupter of genetic equilibrium, but the effect on a population is hardly more than theoretical. The book does not make it clear that because the mutation rate for any given allele is so low, mutation itself has little probability of significantly changing the gene frequencies in population. The text does correctly state that mutations are the ultimate source of variation in a population, and provide variation for natural selection to work on. Unfortunately, the only example given is of deleterious mutations, which further reinforces the "bug-eyed monster" scenario of mutation that students carry into class with them; in fact, most mutations are neutral.

Genetic drift is correctly defined and the example in the chapter is clear, but the "Demonstration" suggested to the teacher may lead to confusion. The teacher is directed to show students pictures of different organisms of a species, and ask students "how removing organisms from a population affects evolution." The answer in the book is, "[i]n each case the genes of the population that are removed disrupt the overall gene frequency." Wrong. The overall gene frequency will be disrupted only if the individuals being removed collectively are different in gene frequencies from the group average. If individuals representing a random sample of genes are removed, the gene frequency of the parent population will not change in the next generation.

Definitions

The glossary's definition of "evolution" is clearly insufficient: "[a] continuing process of genetic change in a population of organisms over long periods of time." A genetic definition of evolution of "change in a population" should at least include the idea of directional, or cumulative, change. In Chapter 2, evolution is introduced as "a gradual genetic change in a population of organisms," without adequately defining "gradual." A stab is made with "many generations," and although this may be adequate in discussing microevolution, it clearly fails when considering the evolution of mammals from mammal-like reptiles, for example. Some cognizance of evolution as "descent with modification," the idea that evolution involves common ancestry as well as changes (modification) in gene frequencies, is needed for students to understand this important concept.

A division is properly made between change having taken place, and being well supported, and mechanisms of change. Not much attention is placed on controversies over how evolution takes place, which is a very active research area.

The definitions of many other terms and concepts misstate or omit important elements. Adaptive radiation is defined as "the evolution of a species in an area into several related species having different survival characteristics," which ignores the importance of the environment into which the radiation occurs.

History of Evolutionary Thought

A subsection of Chapter 10 (Evolution) entitled "The History of Evolution" discusses Lamarck and Darwin. The sections are brief, but contain the essentials. Admirably, Darwin and Lamarck are both presented as evolutionists who differed in their explanations of how evolution came about.

Human Evolution

Human evolution is presented skimpily. The authors correctly place humans and modern apes as descending from a common ancestor, rather than humans being "descended from apes." Culture is not defined, but tools of various stages of human evolution are mentioned. A good link is made with earlier material presented on homology and evolution, pointing out that anatomical similarities of primates and humans indicate common ancestry.

There are errors, however. Very few primates brachiate ("swing from branch to branch"), though the text implies this is a basic primate characteristic. Dart's *Australopithecus africanus* was discovered well before the invention of radiometric dating. And the discovery of Lucy did not solve the problem of whether a large brain or bipedalism evolved first: it solved the problem of whether bipedalism or *tools* came first. The section also misleadingly implies that there are few fossils of hominids, when actually they are quite numerous. Also, the extensive branching that took place during early hominid evolution is not discussed at all. This is important to bring out, as it dispels the idea that human evolution was linear.

Origin of Life

The origin of life is not discussed very extensively. Chemosynthesis is defined as "a chemical process in which the energy from reactions between inorganic molecules is used by organisms to synthesize food." I imagine what happened is that inorganic molecule reactions provide energy that is used by the organism, rather than synthesizing "food." Chapter 11 considers the primal soup theory of the origin of life from inorganic compounds, but does not mention the complimentary clay crystals theory. The chapter also states that "life has been present for only a short time in geological terms," yet the diagram shows life present for 3.5 out of 4-5 billion years. Perhaps they mean *complex* life has been around only for a short time.

A very useful diagram outlines the "steps" from the primordial soup through amino acids, microspheres, and protocells to cells containing nucleic acids, with stages where the synthesis has occurred and where it is only experimentally modeled. This is a helpful way to show how very much we *do* know about the origin of life.

THE NATURE OF SCIENCE

Methods of Science

Science is presented appropriately as "both information about nature and a process of finding answers and seeking explanations." Science is seen as a logical, organized way of looking at nature, and in general, the hypothetical-deductive approach to problem-solving is handled clearly. "Scientific Problem Solving" is the title of the section commonly referred to as "the" scientific method, and it consists of acceptable divisions (defining the problem; making and testing hypotheses; making and recording observations; drawing conclusions.)

This is all very positive, but I wish the authors had done more with science as a way of knowing throughout the book, rather than just in the initial chapter. They do not demonstrate explicitly or thoroughly how a particular discovery illuminates the scientific process. For example, they use the falsification of spontaneous generation as an example of how science works, and indeed, it is a good example. They show how the controls used by Redi convinced his peers that large organisms didn't spontaneously generate. Unfortunately, the drawing supposedly showing Spallanzani's repeat of Needham's broth boiling experiment will confuse the students. Spallanzani criticized Needham for not boiling his broth long enough to kill off all the microorganisms and for not sealing his flasks. Needham used corks, which are too porous. Yet the drawing accompanying the text purportedly showing Spallanzani's experiment shows corked flasks.

This textbook does not develop alternate explanations for many subjects. On dinosaur extinction, for example, two ideas, climate change and asteroid impact, are expressed in about a sentence each. No information is presented about the iridium layer or other sources of data that support the impact hypothesis, or some of the fossil evidence that calls it into question. Most of the time, though, there is only one view given, such as the primordial soup origin of life (rather than that plus the clay theory), a unilineal view of human evolution (excluding the adaptive radiation view of early hominid evolution), and so forth.

Experimental research design alone is given much attention. Although the textbook recognizes that science can be done outside of the laboratory, field research is also presented in terms of experimentation. Students will not appreciate observational and descriptive research.

Presentation of Science

Although the book states that "[y]ou might be surprised to find that you often use a scientific approach in solving your own problems," there is little more than this statement to dispel the "scientist as authority" misconception with which students often come to class. There is a "just the facts" feeling to this book, with little evidence given to back up scientific conclusions.

This book does a good job showing that scientists base their conclusions on evidence, reason and logic. The text speaks in terms of scientists hypothesizing and uses language such as "the evidence indicates" something about dinosaur extinction, for example. But when it comes to human evolution, the language becomes equivocal. "Many anthropologists today *believe* that humans evolved in Africa.." and "[s]cientists, however, *believe* that *H. sapiens* also evolved in Africa", and "[m]ost anthropologists *believe* that H.erectus originated in Africa..." and so on. In a book that has no hesitation in calling evolution the organizing principle of biology, this sudden spasm of "believing" scientists in the human evolution section is a mystery.

Alas, there is not much one can point to that is truly exciting, or that appears to consciously be oriented towards grabbing a student and making him say "Wow!" In the forward to the teacher is a sample paragraph from a chapter introduction on the nervous system that is terrific -- but it seems to be the only real grabber. Surely the authors are excited about their field and their profession. Why can't the book reflect this?

Terminology of Science

Scattered throughout the book in the margins of the Teachers Edition are hints to teachers called "Misconceptions," intended to alert teachers to specific issues students are likely to misunderstand. Notably, one of the "Misconceptions" teachers should clarify for students is the difference between the use of "theory" in general parlance and its use in science. I am glad to see teachers reminded to clarify this important term.

I cannot agree completely with some of the definitions used in this textbook. Hypothesis, for example, is a "possible solution to a problem based on all the currently known facts." I prefer a hypothesis to be a testable statement, rather than a "solution." Hypotheses are defined as testable, which is appropriate, but the book confuses hypotheses with low-level theories when it states that hypotheses generate predictions. These are more matters of preference than serious flaws, however.

The text defines a theory as "an hypothesis that is not disproved after many tests." This is confusing. Theories should be more abstract, higher-order explanations and not directly testable, as are hypotheses. The authors do incorporate the idea that theories are "difficult to disprove," however.

Most textbooks do not seem to be using the term "law" anymore, though it is probably useful to define it and get the misconceptions out of students' minds. This book does this well, pointing out that "laws" are just descriptions of repeated events in nature, and are at a lower level than theories, as theories *explain* laws.

Characteristics of Science

The section on the nature of science is brief and important concepts are buried. The empirical nature of science is only implied, and the self-correcting nature of science also is not illustrated. The nature of scientific "truth" and "proof" is not explicitly discussed. Science as a flexible process resulting in ever more accurate explanations of natural phenomena is not fleshed out in this book.

Science, technology, and society are tied together clearly from the first chapter, and an explicit connection is made between public attitudes toward issues and what research is considered appropriate. The book does not shirk ethical and moral questions in the "Developing a Viewpoint" inserts, in which pesticides, toxic wastes, genetic testing, tropical rain forest destruction, and transgenic organisms are among the topics discussed.

Human reproduction is considered in a matter-of-fact manner, though contraception is ignored. There are a few errors. Males and females do not both continue to grow into the early twenties; long bones of females cease to grow shortly after menarche, though males continue to grow Sexually communicable diseases are listed rather clinically, but not much emphasis is laid on how you get them. No information on condoms or other preventatives is presented. AIDS is not discussed with other sexually transmitted diseases, but is given a section in the immunity chapter. Once again, there is no information about how to avoid it.

SUMMARY

This textbook receives high marks for its thematic approach, for running evolution throughout the book, and for an honest and uncompromising treatment of evolution. It fails, however, to show sufficiently the evolutionary relationships between and within groups, and further is diminished by occasional errors and a tendency to get definitions "almost" right. Science as a way of knowing does not run throughout the book, and there are disturbing qualifications, such as the phrase "some scientists believe," in the human evolution section. The hypothetical-deductive method is presented clearly, however. All in all, Merrill's *Biology: Dynamics of Life* is a good, but not outstanding, textbook.

TITLE: *Biology*
AUTHORS: Kenneth R. Miller and Joseph Levine
PUBLISHER: Prentice Hall, Inc., 1991
REVIEWED BY: Eugenie C. Scott

EVOLUTION

Evolution Theory Integrated Throughout the Text

Prentice Hall's *Biology* receives superlatives for its uncompromising treatment of evolution. The textbook presents evolution as a normal, uncontroversial aspect of biology. This is as it should be. In addition to the evolution unit itself, the topic is covered in the units on plants, invertebrates, and vertebrates. Chapters on vertebrates include sections on fish, amphibian, reptile or mammal evolution with no more fuss than they discuss feeding, respiration, behavior, and other characteristics.

Theodosius Dobzhansky once said, "Nothing in biology makes sense except in the light of evolution," and this textbook uses the principle of evolution to make sense of biology. Evolution is truly integrated throughout, and called upon to elucidate both the complexity of biology as well as major concepts. Chapter 30, "Comparing Invertebrates," organizes the enormous variety within this taxon by discussing evolution of the invertebrates. All books discuss ectothermy and endothermy, but few put them in an evolutionary context as does this one.

In this textbook, taxonomy is based on homology, consistent with the practices of modern biologists. A review question asks, "Why did evolutionary theory prove important in taxonomy?" as a passage relates that "taxonomists attempt to group organisms in ways that show their evolutionary relationships. Taxonomists do this by identifying and studying homologous structures in adult organisms, in developing embryos, and in well-preserved fossils."

Anatomy is a topic handled separately in each section, as this book is organized along taxonomic (what publishers inaccurately call "phylogenetic") lines. Skeletal and other systems of organisms are discussed by group of organism, and there are references when appropriate to similarities and differences among the phyla. Because the chapters also include separate sections on the evolution of the organism, students will be in a good position to appreciate the evolutionary associations among various taxa.

Evidence for Evolution

This subject is handled extremely well in this book, especially for vertebrate, but it is not neglected in invertebrates and plants. Even the evolution of protists is not ignored, and fossil ferns are depicted in the section on plants, not only in the chapters specifically on evolution. A section on evolution occurs in each chapter on each major vertebrate taxon (fish, amphibians, reptiles, mammals), plus sections in the plant unit on the invasion of the land by plants, seed plant evolution, and angiosperm and animal coevolution. *Biology* shows particularly well the connections among taxa, not just presenting each taxon anew.

Chapter 13 discusses geological dating methods, fossils, comparative anatomy (homology), and biochemistry as sources of evidence for evolution. The sections are adequate, though not extensive. Chapter 14 ties in an earlier unit on genetics to show the relationship between modern genetic knowledge and mechanisms of evolution.

Mechanisms of Evolution

Natural selection is presented as the major mechanism of evolutionary change, but importantly, not as the *only* mechanism. It is accurately presented as a result of variation among individuals, the environment selecting for certain variations, and the fitter individuals leaving more offspring. Unfortunately, the historical term, "survival of the fittest," is used. "Survival of the fittest" has a "nature red in tooth and claw" connotation for many students that is inaccurate -- and actually, so is the phrase itself. In reality, natural selection is survival and reproduction of the fit *enough*; the ones who pass on genes are not only the "superlatives." Natural selection is mentioned frequently throughout the text, where appropriate.

Adaptive radiation is especially well handled, being accurately defined and tied to other concepts and references. It is directly tied to speciation, for example, which itself is discussed extensively. Species are accurately defined as reproductively isolated groups, and Darwin's finches are given as an example of both speciation and adaptive radiation. To the textbook's credit, it discusses genetic drift extensively, whereas many textbooks assume natural selection is the be all and end all of evolutionary causes. Something especially nice about this book is that it makes clear that a population or species undergoing competition for resources may have three possible fates: it can evolve, it can coexist, or it can become extinct.

Punctuated equilibria is given a thorough discussion, and is correctly presented as an alternative to Darwinian gradualism. The discussion is accurate, and the authors are clear about the still evolving place of punctuated equilibria theory among biologists.

Definitions

The text is clear that the term evolution is used to describe the fact that change has taken place throughout earth's history as well as the mechanisms that explain that change. "Evolutionary change is undeniable. Evolutionary theory is a collection of carefully reasoned and tested hypotheses about how evolutionary change occurs." "But whatever the pace of change might have been, it is certain that organisms have evolved over time."

The glossary includes both of the components of the definition of evolution: that evolution refers to the concept of shared common ancestry as well as the genetic definition.

One slip in an otherwise careful book is a reference to seed plants being "designed for life on land." Surely a better verb could have been chosen than one that connotes the supernatural.

History of Evolutionary Thought

Darwin's discovery of evolution by natural selection is handled accurately and completely. The roles of Malthus and Lyell are developed, and the explication of how Darwin developed natural selection theory is handled as a process of problem solving using the scientific method. It is well done.

Lamarck's views are presented in historical context. While the book commendably points out the role of modern genetics in "disproving" Lamarck, it still honors him as an early evolutionary theoretician.

Human Evolution

It should not be necessary to tell students that the Flintstones are not an accurate portrayal of human evolution, but it is, and it is probably good that this book does so! Indeed, humans and dinosaurs did not coexist. Primate evolution as well as human evolution are included, and the coverage is detailed. There are good tie-ins between data and conclusion: "Charred animal bones have been found around fire sites. This shows that *Homo erectus* must have used fire for cooking." Neanderthals are portrayed accurately not as hunched-over, beetle-browed primitives, but as intelligent humans who were nonetheless less evolved than their successors. Cultural evidence is discussed, though no illustrations are presented.

Unfortunately, transitions between the major stages of evolution are not made clear. Australopithecines occur and become extinct, and then *Homo habilis* shows up, with no indication that some of the former gave rise to the latter. Then *H. habilis* shows up, disappears, and "was replaced by a larger brained species called *Homo erectus*." But did habilines *evolve* into erectus? One cannot tell from the text, and this is a shortcoming.

Origin of Life

The origin of life warrants a separate chapter, and the attention paid to this interesting question is commendable. Studies on spontaneous generation are traced historically, and lead to a complete discussion of the formation of life. Both the organic soup theory and Cairns-Smith and Bernal's clay crystal theory are discussed, as well as the evolution of autotrophy, photosynthesis, eucaryotes, procaryotes, and aerobic metabolism. This is one of the more complete treatments of early evolution one will find in a high school textbook.

NATURE OF SCIENCE

Methods of Science

Prentice Hall's *Biology* describes the hypothetical-deductive method (here called "The Scientific Method") quite clearly in the first chapter, with examples of the various components. Although the procedure is stated in steps (observing and stating a problem; forming an hypothesis; testing an hypothesis; recording and analyzing data; forming a conclusion; replicating the work), a student is not made to feel that these rules are hard and fast. After listing these steps the very next sentence is "[t]o the true scientist, however, the scientific method is more a frame of mind -- a frame of mind that involves curiosity."

This book adequately presents alternate explanations for areas of science where the jury is still out. Like most texts, more can be done to provide data and reasoning supporting different points of view.

Experimental research design is given the bulk of attention in the first chapter, though the summary does describe hypothesis testing "through observation or experimentation." Elsewhere in the book, observational hypothesis testing is common, but it is not made explicit as it should be.

Presentation of Science

Authoritarianism is consciously avoided throughout this book, beginning in the first chapter describing science. Science is clearly stated as a process, rather than a priesthood. The authors are quick to remind the students that science is in use around them every day by ordinary people and even themselves. It is good for students to have science defined as "organized common sense," which is repeated many times through the book.

Scientific findings are often presented as the result of someone's work, and the thinking and observations that went into the conclusion are frequently presented. This, too, helps make science a human endeavor rather than something that comes ready to memorize out of books.

In general, conclusions are backed with evidence; this textbook is better than many. There are places where, with only a bit more effort, a conclusion could have been supported with data, for example, in the diagram of cytochrome c used to illustrate taxonomy through biochemistry. Even if students weren't given a full explanation of how such conclusions are arrived at, it would have helped to put numbers at the branches to indicate that such conclusions are supported by data.

There were several statements qualified with the phrase "many scientists believe" in an otherwise excellent unit on evolution, which is puzzling because the textbook presents evolution honestly and with conviction. Why don't the authors use more accurate verbs like "hypothesize," "infer," or "deduce?"

This book shines brighter about the joy of science than just about any other I have read. Truly, it is an educationally benumbed student who would be incapable of being inspired by this book. The two authors make it clear by both example and statement that science is fun and that scientists enjoy what they do. Students are encouraged to go forth and make sense of the world themselves, and these challenges are presented with enthusiasm and encouragement.

At the end of each unit are personal statements from Miller or Levine that humanize the subject. They talk about experiences they had as students themselves, or of their respective love of nature, or statements of personal philosophy that don't come across as preachy grownups talking. They are friendly and informal. After the unit on heredity, for example, author Miller reflects on the "nature/nurture" problem, concluding, "When you think about the men and women who have pioneered scientific research, dreamed up inventions, written great literature or music, what do you see? Great genes or great efforts? The answer, without a doubt, is the latter. What we inherit is the beginning of what we can be. It is not the end of it."

Terminology of Science

The authors don't use the terms hypothesis and theory consistently or correctly. Hypothesis is defined as "a possible explanation, a preliminary conclusion, or even a guess about some event in nature." To say a hypothesis is a "guess" does not imply the empirically-based observations, knowledge, and preliminary thought that goes into formulating an hypothesis. "Guess" implies "your guess is as good as mine," and therefore astrology is as good as astronomy. They make amends by noting that an hypothesis is generated after some information is gathered and is tested against observation, but they need to clarify that an hypothesis is not a guess in the sense that students hear the word "guess."

Their definition of theory is likely to confuse students. "When an hypothesis is tested and confirmed often enough that it is unlikely to be disproved by future tests, it may become worthy of being called a theory." Thus a theory is a tested and confirmed hypothesis. Then, "In scientific usage, the word theory means a great deal more than it does in common speech. Scientific theories are not just hunches or hypotheses." So now theories are *not* hypotheses. What are they? "They are powerful, time-tested concepts that make useful and dependable predictions about the natural world." Now they are *concepts*. These definitions need a little polishing.

Characteristics of Science

This book is quite strong on the empirical basis of science, and clearly presents science as a way of knowing based on testing ideas against evidence. The discussion of the discovery of viruses is presented as an example of how science works, and is especially nicely done.

This book is exemplary in its presentation of scientific conclusions as tentative and likely to change with new data and theory. Importantly, this idea is presented as a positive, rather than a negative aspect of science: "Many scientific facts of the past are now known to be false...Yet this does not mean that science has failed....Science is not a collection of eternal truths. Rather, it is a process, a way of looking at and understanding the world. And science will continue to change as long as humans wonder about the universe."

A criticism is the use of the term "proof." Hypotheses are not "proven", rather they are corroborated or confirmed. Occasionally the authors lapse into this inaccurate terminology, which does not match the otherwise admirable presentation of the tentativeness of scientific "truth."

The textbook profusely covers science, technology and society issues. In addition to presenting applications of science and technology (copper mining with bacteria, leeches in modern medicine, robot appendages built on the principle of squid tentacles, etc.), they also present controversial issues in conservation and bioethics (pesticides in agriculture, destruction of tropical forests, infant formula in the third world, the use of human subjects in medical research). The chapter on drugs is straightforward and descriptive. There is a nice, juicy picture of cancerous alveoli that should get a student smoker's attention, but in general, the treatment is not preachy -- and therefore probably more effective. Human reproduction is presented in a matter-of-fact way; it warrants no more fuss than the reproduction of any other organism.

SUMMARY

While none of the textbooks reviewed is perfect, and probably no book can be, Prentice Hall's *Biology* is closer to perfection than most. Its treatments of both evolution and science as a way of knowing are outstanding. Both topics are presented clearly and in an engaging fashion that will encourage and stimulate students.

TITLE: *Biology : The Study of Life*
AUTHORS: William D. Schraer and Herbert J. Stoltze
PUBLISHER: Prentice-Hall, Inc., 1990
REVIEWED BY: Wayne A. Moyer

GENERAL

The text is divided into eight units: "Introduction to biology"; "Animal Maintenance"; "Plant Maintenance"; "Reproduction and Development"; "Genetics;" "Evolution"; "Diversity of Living Things"; and "Ecology."

The material is organized in a linear fashion, from the molecular level to ecology. The introductory unit covers nature of life, chemistry, the cell, cellular respiration and classification. The authors then turn their attention to the organism with a comparative review of animal physiology, with emphasis on human systems. The structure and function of higher plants is treated in three chapters, followed by mitosis, meiosis, animal development, human reproduction and sexual reproduction of plants. Evolutionary theory is covered next, followed by a seven chapter march through the phyla that ends with a chapter on animal behavior. The text concludes with ecology, including biomes of the earth and human ecology.

EVOLUTION

Integration Throughout the Text

Evolutionary theory appears in several chapters of this textbook, but by no means is it fully utilized as an explanatory mechanism of biology. The chapter on taxonomy, which appears early in the book and long before the chapters on descriptive taxonomy, is based on evolutionary concepts. For example, the chapter ends with this statement: "[a]s you have read in this chapter, the modern taxonomy system attempts to arrange organisms into groups that reflect their heredity and, therefore, evolutionary relationships." Evolutionary theory itself is explicated in two meaty chapters.

However, evolutionary theory is not mentioned in the six-chapter survey of the phyla, and proposed phylogeny of taxa are noticeably absent. Furthermore, evolutionary theory is not referred to in the chapters on comparative physiology, nor in the chapters on ecology or world biomes.

Evidence for Evolution

The first of the two chapters on evolutionary theory deals entirely with the evidence that organic evolution has occurred (the authors correctly distinguish between organic and geologic evolution, a point often neglected). There is an excellent section on fossilization and the process of dating, both relative and absolute. Index fossils are described and a geologic time scale is included. Two important generalizations are made: that disconnected strata can be linked by index fossils to create a continuous time-line, and that there is an increase in complexity as one moves from ancient fossils to more modern ones. Homology, comparative embryology and comparative biochemistry are cited as evidence of relatedness, implying a common ancestor.

This chapter is somewhat disjointed, with a lengthy but well-written section on spontaneous generation and the origin of life on earth being dropped in as if the publisher could not find another place for the topic. This chapter would be improved by inclusion of the basic question: how can we account for the great diversity of both modern and fossil life-forms?

Mechanisms of Evolution

As previously noted, the authors have cleanly separated evidence supporting any hypothesis of evolution from explanations of how it occurs. Darwin's argument for natural selection is well presented, although it could be strengthened by reference to his studies on selective breeding. Punctuated equilibrium is introduced as an argument over the rate of evolutionary change, rather than an alternative to natural selection. The synthetic theory of evolution is lucidly presented, with arguments drawn from population biology and the Hardy-Weinberg law. Sources of variation cited include mutations, recombination, genetic drift and migration. Types of natural selection are discussed, although with what I consider to be weak examples: giraffes to illustrate directional selection, mouse size to illustrate stabilizing selection (contrary to the text, larger animals actually use less energy to keep warm than smaller ones), and disruptive selection.

Speciation gets its own section (a plus) with effects of range, isolation and adaptive radiation being discussed. Industrial melanism, resistance to antibiotics -- with an excellent review of the Lederberg's experiment with bacteria -- and DDT resistance in insects are reviewed. In addition, the chapter on modern genetics notes that polyploidy can lead to a new plant species in one generation, sickle cell anemia is selected for by the presence of malaria, and that mutations are a source of genetic variation.

Definitions

The text and glossary definitions related to evolutionary theory are generally good. Natural selection is defined as, "the process whereby organisms with favorable variations survive and produce more offspring than less well-adapted organisms." Evolution is defined as, "gradual change in allele frequency found in a population." This, in my opinion, is weak, and better describes what some people refer to as "microevolution."

Similarly, I object to the glossary definition of evolutionary theory: "theory of gradual change in species over time." Both fail to grasp the sweep and scope of organic evolution.

History of Evolutionary Thought

The authors do a creditable job of reporting the history of major ideas in biology, such as evolution, molecular genetics, and the like. Lamarck's ideas are presented accurately, along with Weisman's experimental refutation. Darwin's voyage on the *Beagle*, the influence of Lyell's work and the contribution of Malthus are included. However, I missed any discussion of the age of the earth, either in connection with Lyell's work or in the discussion of radiographic dating.

Human Evolution

This topic receives a seven-page section at the end of the chapter on Vertebrates -- Birds and Mammals. Primates are defined and the distinguishing characteristics of hominids given. The history of discoveries of human fossils are recounted, including *Australopithecus, H. habilis, H. erectus*, Neanderthals and Cro-Magnons. Hypothesized pathways for human evolution are given. Altogether a good treatment, although the authors might have made reference to sickle cell anemia and studies of other variations found in human populations as examples of natural selection.

Origin of Life

For a reason known only to the publisher and about which I will speculate later, spontaneous generation and the origin of life on Earth are covered in the chapter titled, Evidence of Evolution. The presentation is straightforward, beginning with van Helmont, and continuing with Francesco Redi, van Leweuwenhoek, Needham, Spallanzani and ending with Pasteur. The heterotroph hypothesis is reviewed along with Miller's classic experiment.

NATURE OF SCIENCE

Methods of Science

The methods of science are well described in chapter two, with the significance of theory, hypothesis, and scientific laws (as descriptions of phenomena) described. However, the authors utterly fail to employ the method they have so carefully presented in any of their laboratory investigations. This is a serious fault. To their credit, they include "Problem Solving Exercises" and "Critical Thinking" boxes which help students understand more about scientific investigation.

Chapter 2 also contains fairly detailed descriptions of modern scientific apparatus, including light and electron microscopes, and techniques such as centrifugation, chromatography and spectroscopy. In my opinion, these important concepts should be introduced as they are needed to explain how we know what we do about living things, rather than in an introductory chapter.

Presentation of Science

The authors give altogether too much vocabulary, which only serves to trivialize the content and encourage too many recall questions at the end of each chapter and, undoubtedly, on teacher's exams. Technical vocabulary should be used only when everyday language fails to convey the concept accurately. Even then, the term should be used more than once.

A related problem is the predominance of the direct mode of instruction employed by the authors, which seems to say to students, "This is science; learn it!" While this text is better than most in this regard, alert teachers will have to rephrase some of the passages into a series of challenging questions on the general theme, "But how do we know?"

Perhaps this is the place to voice a small but annoying complaint. The publisher rarely gives the magnification for the many fine illustrations. Besides being decidedly unscientific, it leads students into serious misconceptions, especially when interpreting photomicrographs.

Terminology

Hypothesis is nicely defined as, "possible explanation for an observed set of facts," and theory as, "explanation based on facts that apply to a broad range of phenomena." Evolutionary theory is defined acceptably as "theory of gradual change in species over time." In the explanation of the binomial nomenclature, the authors commendably use the correct terminology: the first name identifies the genus while the second identifies the species within the genus. Together they constitute the species name.

Characteristics of Science

The authors do a better than average job of describing the self-correcting nature of science and the importance of publication to this process.

SUMMARY

This is a well written and produced textbook, one which represents a clear improvement over some recent examples. While there is an excess of vocabulary, a teacher does not have to assign all of it, or all of the recall questions. The authors have included a number of clever higher level questions at the end of each chapter which can be used as alternatives.

On the negative side, the authors (or more likely, the publishers) have tried to be all things to all people. Thus, there are extensive sections on human biology and the traditional march through the phyla that are apt to be repeats of what students have already studied in grade seven life science. I also found the evolutionary theory, while well covered, is carefully segregated into certain chapters and sections, where the material can be ignored, if a teacher or administrator so chooses.

ABOUT THE REVIEWERS

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