The Emphasis Given to Evolution in State Science Standards: A Lever for Change in Evolution Education?

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ABSTRACT: This study analyzed the science frameworks of 49 states and the District of Colombia to determine the emphasis given to evolution in these documents at the middle and secondary levels. These concepts were species evolve over time, speciation, diversity of life, descent with modification from common ancestry, evidence of evolution, natural selection, pace and direction of evolution, and human evolution. Collectively, the 50 science frameworks emphasized evolution in a manner that suggests that if the public’s support for standards-based curricula is a reality, the study of evolution will be emphasized in an unprecedented manner in the nation’s schools in the near future. However, all concepts were not emphasized equally in these documents. For example, human evolution was included in only seven documents. The word evolution is absent from some standards. Despite these negatives, recent actions to improve existing standards or to adopt new standards that emphasize evolution have occurred. The metaphor “lever of change” is often used in the context of school reform. This metaphor suggests a simple system where one change can result in a desired outcome. However, in classrooms where curriculum decisions evolve constantly, multiple factors interact and reinforce one another in response to both internal and external contingencies that emerge. Educational change can not be reduced to a simple linear cause/effect situation. The change process involved is nonlinear where what goes in is not proportional to what comes out because of feedback loops and other factors that complicate results. This nonlinearity is reflected in the varied responses of teachers to specific contingencies. Yet, systems can be changed and nudged towards a structure where desired outcomes will emerge. Judicial rulings indicating that the teaching of evolution cannot be prohibited or equal time for creationism mandated, improved coverage of evolution in secondary school biology textbooks, the negative response of many leaders, scientists, organizations, and editorial writers to the 1999 decision of the Kansas State Board of Education to deemphasize and misrepresent evolution in the state’s science standards, and the emphasis given to evolution in the standards reviewed for this study, all coalesce to provide needed support for administrators and teachers who are striving to create science curricula.

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that emphasize evolution in a manner commensurate with its importance in understanding
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INTRODUCTION

Charles Darwin’s monumental book *Origin of Species* introduced evolution to the crit-
cical eye of the public in 1859. Criticism of his work and the concept of evolution were
instantaneous and intense. The controversy that emerged from this publication has never
completely subsided and has impacted science curricula during much of the twentieth cen-
tury. The historical record of the public debate regarding evolution is rich with information
regarding the swinging pendulum of support for evolution in schools. For example in the
1920s, 37 legislative bills proposing to make the teaching evolution in public schools illegal
were introduced in 20 states (Johnson, 1954). While these and later legislative efforts were
mostly unsuccessful, they combined with other forces and activities to intimidate teachers,
policy makers, and textbook publishers. This intimidation was reflected in a steady stream of
high school biology textbooks that failed to emphasize evolution in a manner commensurate
with its status as a unifying concept in biology (Skoog, 1979, 1984). For example, 33 of 66
biology textbooks published between 1900 and 1960 failed to use the word evolution in the
text (Skoog, 1979). Since the 1960s, the textbook coverage of evolution has become more
comprehensive but the persistent pressures of antievolutionists to eliminate or neutralize the
teaching of evolution have impacted textbooks, as well as science teachers (Skoog, 1984,
1992). Recent studies in Ohio (Zimmerman, 1987), Texas (Shankar, 1989), and Louisiana
(Aguillard, 1999) provide evidence that most biology teachers fail to emphasize evolution
as advocated in *Teaching About Evolution and the Nature of Science* (National Academy
of Sciences, 1998, p. 3), which asserted “evolution is the central organizing principle that
biologists use to understand the world” and to “teach biology without explaining evolu-
tion deprives students of a powerful concept that brings great order and coherence to our
understanding of life.”

The inclusion of science within current education reform efforts reflects the public’s
recognition of the importance of science literacy in today’s society. The standards-based
instructional movement has influenced current reform initiatives, including those in science
education. This movement gained impetus from the policy makers and educational leaders
who influenced the development of *Goals 2000: Educate America* and asserted that by
the year 2000, American students will be “first in the world in mathematics and science
achievement” (Goals 2000: Educate America Act, 1994). While the role of federal initiatives
in formulating standards has faded, 49 states and the District of Columbia have formulated
standards and curriculum frameworks (Olson, 2001). These curriculum frameworks have
been influenced by *The National Science Education Standards* (National Research Council,
1996) and Project 2061’s *Benchmarks for Scientific Literacy* (American Association for the
Advancement of Science, 1993).

National and state standards have the potential to influence all aspects of educational
policy and practice inasmuch as they are designed to provide vision for science educa-
tion, organize content, transform teaching practice, provide equity in the classroom, and
link policy and subject content (Blank, 1996). The importance of science standards and, in
particular, the treatment of evolution, is evidenced by the widespread interest and contro-
versy that erupted when the Kansas State Board of Education in August, 1999 approved
science standards that included only certain aspects of evolutionary theory (Holden, 1999).
This decision had instructional implications as the standards provide the basis for a future
statewide testing program in science.
State standards have the support of the public (Doyle, 1999; Quality Counts 2000, 2001). This is not altogether surprising inasmuch as the national and state standards are policy documents developed through a political process (Bybee, 1997; Collins, 1998; Lerner, 2000) and, as such, tend to represent a consensus that reflects a wide and diverse audience. Because of the importance of state standards in shaping curriculum decisions and the growing public support of state standards, the absence or presence of concepts concerned with evolution provide evidence of whether the historical marginalization of evolution in the science curriculum is continuing or being diminished.

State standards frameworks vary as their development are guided by a variety of philosophies and independent historical precedents. Some standards have brief, concise descriptions of overall content or process that establish a general direction without unnecessary prescription. Other frameworks tend to be more comprehensive regarding content topics, process skills, and, often, pedagogical expectations. The organizational structure of the frameworks also varies. Interestingly, almost every document includes some hierarchical structure consisting of a content or process standard followed by (or, in some cases, contained within) benchmarked grade levels. Beyond benchmarks, however, the methods employed in organizing the “big picture” content or process skills vary considerably. There are three overall patterns of organization: (1) an integrated approach to science standards, (2) a discipline or subject matter structure, or (3) a developmental structure emphasizing grade level over specific content. In some cases, states mixed two or more of these approaches, using a developmental approach at the middle grades, but shifting to a subject matter organization at secondary level.

A detailed description of these three organizational approaches was beyond the scope of this study, but it is important to note that the differences in style directly influence how science standards are explained, described, and, subsequently, interpreted and used. Standards framed within the contexts of separate disciplines, such as biology or chemistry, are specific to that content area whereas standards developed in an integrated format tend to be broader in scope and, consequently, less descriptive of specific concepts.

**PURPOSE**

The purpose of this study was to determine the emphasis given to concepts of evolution in available state science framework documents for middle and secondary levels. The state standards documents were the focus of this study because of their potential to produce curricular change. The frameworks represent the vision for science as conceived in a political process by diverse groups of people within each state, from policy makers and university professors to teachers and parents. Each set of standards has been reviewed, discussed, and eventually accepted by these same eclectic voices, and arriving at consensus by the multifaceted groups represents a true accomplishment. When the difficult process of consensus is achieved, and evolutionary concepts remain intact and accurately expressed within the standards, science educators can feel confident that they have the support of many groups within the state to teach evolution. This type of public statement in support of evolution would represent a milestone.

**METHODS**

Science standards from 49 states and the District of Columbia (which will be termed a state in the discussion and data that follow) were analyzed. Iowa is the only state without standards. Most of the curriculum frameworks were accessed from online sources.
In order to maintain a centralized focus on evolution within the standards, only a select group of salient concepts related to evolution were considered. No effort was made to review and evaluate each document as a whole. Because of the eclectic nature of the science frameworks, it is impossible to draw stringent and reliable comparisons between state-curriculum documents. Instead of focusing on comparisons, as have several other analyses of science standards (American Federation of Teachers, 1997; Finn, Petrilli, & Vanourek, 1998; Lerner, 2000), this study emphasized each state document’s individual merit as determined by the inclusion of salient concepts or topics deemed central to understanding evolution. The intention of this study, therefore, was to evaluate the overall progress that has been made in incorporating evolution into the state science standards and frameworks. Considering the narrow scope of this content analysis, we caution anyone who might be tempted to draw rigid comparisons between state documents.

To establish a framework for assessing the emphasis on evolution within state science standards, a select group of concepts related to evolution were adapted from the National Science Education Standards (National Research Council, 1996, p. 185), which emphasizes evolution as a unifying concept. These concepts are as follows:

1. **Species evolve over time.** Change over time occurs within species because of interaction of environmental and genetic factors.
2. **Speciation** occurs as modification within a single species over time that eventually leads to the inability of once-related species to interbreed. Geologic isolation and reproductive isolation are examples of processes that lead to speciation.
3. The **diversity** of organisms evident today is due to evolution. On the larger ecological scale, the existence of the diverse species on earth, today, is direct result of the evolution of species over time.
4. Organisms share some characteristics because of **descent from common ancestors**. As speciation occurs, new species will share characteristics with other closely related species because of their shared ancestors. This process is also understood as **descent with modification**, implying that a series of long-term changes accumulate over time leading to entirely new species.
5. Molecular, anatomical, and genetic **evidence** exists for evolution. Evolution provides a scientific explanation for the fossil record, genetic similarities, and anatomical similarities between species. These records provide a source of information regarding the length of time required for evolution to occur as well as the degree of relatedness between species.
6. **Natural selection** is the mechanism through which evolution occurs. Natural selection incorporates concepts of population, variation and mutation, and survival.
7. Current evolutionary thinking supports multiple theories regarding the **pace and direction** of evolution. Evolutionary experts still debate the pace and direction of evolution. Some scientists argue that evolution is punctuated or that it has “fits and starts”; whereas, other scientists contend that evolution occurs at a relatively constant rate over time. In addition, evolution of a species does not necessarily infer a “progression” for that species. Evolution occurs because of environmental and genetic factors that directly influence a species and those factors change over time. Accordingly, evolution occurs without any set direction or sense of advancement.
8. **Humans have evolved over time.** Humans, like all other organisms, have an evolutionary history that includes change in species over time. Humans share characteristics with other concurrent living things because of shared ancestors. Humans are a single species.
The presence of these central tenets in state standards would provide evidence that evolution has attained its status as a unifying theme in science, as envisioned by the National Science Education Standards (National Research Council, 1996), Scope, Sequence, and Coordination project (National Science Teachers Association, 1992) and Project 2061’s Science for All Americans (American Association for the Advancement of Science, 1989). States whose science standards centralize the role of evolution also should demonstrate an undeniable commitment to the unfettered study of evolution in each and every classroom.

Data from the studies in Ohio, Texas, and Louisiana cited earlier (Aguillard, 1999; Shankar, 1989; Zimmerman, 1987) indicated teachers do not emphasize each of these eight topics or areas in an equal manner. Undoubtedly, the complexity, perceived importance, and potential to arouse controversy resulted in differentiated treatment of these topics. In this study, these essential concepts served as a dipstick with which to examine the state science frameworks and to assess the emphasis being given to evolution in policy documents.

EMPHASIS ON EVOLUTION: AN OVERVIEW

Collectively, the 50 science framework documents emphasized evolution in a manner that suggests if the public’s support for standards-based curricula is a reality, the study of evolution will be emphasized in an unprecedented manner in most of the nation’s schools in the near future (Table 1). Forty-six (92%) of the middle and secondary level science frameworks included the overall concept that species change over time as well as the concept of natural selection. The concept that the diversity of organisms evident today is due to evolution was emphasized in 45 documents. The evidence for evolution is emphasized in 38 (76%) of the frameworks. These data provide strong evidence that key concepts or elements concerned with evolutionary theory are receiving a significant emphasis in state policy documents.

However, there is still not full inclusion of important aspects of evolutionary science in the science curriculum. Descent with modification was present in only 21 (42%) of state documents. Human evolution, arguably one of the most controversial topics in evolutionary theory for many individuals, was included in only 7 (10%) of the state curriculum frameworks. These data are consistent with the studies indicating that 69% of Louisiana biology teachers (Aguillard, 1999, p. 188) as well as 69% of Texas biology teachers (Shankar, 1989) allocated 30 or fewer minutes to human evolution during an academic year.

EMPHASIS ON EVOLUTION: A CLOSER LOOK AT THE CONCEPTS

Species Change Over Time

The general concept that species change over time was emphasized in 46 out of the 50 science frameworks examined. The language used typically was direct and free of restrictive

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<td>92% (n = 46)</td>
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<td>90% (n = 45)</td>
<td>76% (n = 38)</td>
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language. Some of the representative standards follow:

- Explore and illustrate that in both the short and long term (millions of years), changes in the environment have resulted in qualitative and quantitative changes in the species of plants and animals that inhabit the Earth. (Massachusetts)
- The basic idea of biological evolution is that the earth’s present-day species developed from earlier, distinctly different species. (Rhode Island)
- Explain the basic idea of biological evolution. (Hawaii)
- ... the theory of biological evolution is that through genetic and/or environmental influences the Earth’s present-day species developed from earlier, distinctly different, but common ancestors. (Nevada)
- Students recognize evolution as change over time in relation to astronomical, geological, technological, and biological systems. (Wyoming)
- Know that the theory of evolution explains how species evolve over time and how evolution is the consequence of interactions of ... (Idaho)
- Species change through time and new life forms evolve. (Arkansas)
- Individual organisms and species change over time. (New York)
- Biological evolution accounts for the diversity of species developed through gradual processes over many generations. (California)

Recent changes strengthened some standards. The 1997 Arkansas standards mandated that students “Describe how biologists might trace possible evolutionary relationships among present and past life forms” (Arkansas Department of Education, 1997, Life Science Systems Grades 5–8, 4.1.17) whereas the 1999 standards state “Understand that all living thing contain similar genetic material that evolves because of gene mutation, natural selection, and change in environments. Species change through time, and new life forms evolve” (Arkansas Department of Education, 1999, p. 21). The 1996 New Mexico standards (New Mexico State Department of Education, 1996) indicated students will “Perform a critical scientific analysis of theories of biological origin based on direct observations, investigations, or historical data that accounts for the present form and function of objects, organisms, and natural systems.” In 1999, this statement was replaced with “Employ the concept of evolution as a series of changes, some gradual and some sporadic, that account for the present form and function of objects ranging from microorganisms to galaxies; and, describe the general idea of evolution as the present arising from materials and forms of the past” (New Mexico State Department of Education, 1999). In 1999, standards approved by the Kansas State Board of Education gave minimal and misleading attention to evolution. These standards differentiated between microevolution and macroevolution and stated that “Over time, genetic variation acted upon by natural selection has brought variations in populations. This is termed microevolution” (Kansas State Department of Education, 1999, Dec). A new board in February 2001 restored evolution to the standards in a credible manner and the aforementioned statement was changed to “Biological evolution, gradual changes of characteristics of organisms over many generations, has brought variation among populations and species” (p. 38).

Some standards provide evidence that the longstanding pressure of antievolutionists continues to influence policy makers. Statements from the National Science Education Standards appear in many state frameworks and editing that occurs is quite noticeable. For example, Kentucky’s content standards have three statements in the Biological Change section that are taken directly from The National Science Education Standards life science (9–12) standards. The words evolution, evolve, and evolutionary, which collectively were used six times in the NSES statements, were either replaced with change or change over time or deleted in the Kentucky standards (Kentucky Department of Education, 1999, Sept).
Minnesota standards, which are concise, also use “change over time” in lieu of “evolution” (Minnesota Department of Education, 1999). Several states failed to include the word evolution in the standard.

The presence of the basic and important concept that life evolves in the majority of the documents (90%) represents significant progress in the century-long struggle to have evolution emphasized in science curricula in a manner commensurate to its importance as a unifying concept in biology.

Diversity

Forty-five standard frameworks include references to diversity. Conceptually, diversity can be emphasized in various contexts and in different ways within biology curricula. In this content analysis, a broad interpretation of the diversity concept was maintained. Thus, a curriculum document did not necessarily have to situate the diversity concept securely within evolutionary references but could situate the concept within a variety of contexts.

Representative standards for this concept follow:

- The natural world consists of a diversity of organisms that transmit their characteristics to future generations. Students will study how living things reproduce, develop, and transmit traits, and how theories of evolution explain the unity and diversity of species found on the Earth. (Delaware)
- Inquiries into evolution explain the ways in which natural processes produce life’s diversity. (Colorado)
- Investigate and use the theory of evolution to explain diversity of life. (Nebraska)
- Understand how the theory of biological evolution accounts for the diversity of species and the changes in species over time. (Washington)
- Biological evolution accounts for the diversity of species developed through gradual processes over many generations. (California)
- . . . the evidence that the great diversity of life is the result of more than 3.5 billion years of natural selection and biological evolution, which have filled every available niche with life forms. (New Mexico)

The document *Teaching About Evolution and the Nature of Science* (National Academy of Sciences, 1998, p. 3) states that “biological evolution accounts for three of the most fundamental features of the world around us: the similarities among living things, the diversity of life, and many features of the physical world we inhabit.” Overall, there is evidence that the fundamental relationship between evolution and diversity is emphasized in most state science frameworks.

Natural Selection

The document *Teaching About Evolution and the Nature of Science* (National Academy of Sciences, 1998, p. 16) asserts that “The concept of evolution through random genetic variation and natural selection makes sense of what would otherwise be a huge body of unconnected observations.” Forty-six of the state frameworks recognize the importance of the centrality of natural selection in understanding evolution and the natural world by including related standards.

Representative standards follow:

- Natural selection is the process by which some individuals with certain traits are more likely to survive and produce greater numbers of offspring than other organisms of
the same species. Conditions in the environment can affect which individuals survive in order to reproduce and pass on their traits to future generations. (Delaware)

- Describe ways in which genetic variation is preserved or eliminated from a population through natural selection. (Massachusetts)
- Know that natural selection and its evolutionary consequences provide a scientific explanation for the fossil record of ancient life forms, as well as for the striking molecular similarities observed among the diverse species of organisms. (Idaho) (South Carolina has an identical standard that has “living” organisms.)
- Explain how a new species or variety may originate through the evolutionary process of natural selection. (Michigan)
- Natural selection and its evolutionary consequences provide a scientific explanation for the fossil record of ancient life forms, as well as for the molecular and structural similarities observed among the diverse species of living organisms. (New York)
- Evaluate the theory of natural selection: survival in particular environments, fossil and genetic records; climatic events. (Alabama)
- Natural selection provides the mechanism for evolution: Some variation in heritable characteristics exists within every species, some of these characteristics give individuals an advantage over others in surviving and reproducing, and the advantaged offspring, in turn, are more likely than others to survive and reproduce. The proportion of individuals that have advantageous characteristics will increase. (Rhode Island)
- Explain and justify how natural selection and its evolutionary consequences provide a scientific explanation for the fossil record of ancient life forms. (Vermont)
- Relate the role of natural selection to the development and/or extinction of a species. (West Virginia)
- Recognize that individual organisms with certain traits are more likely to survive and have offspring. (New Jersey)

Speciation

Speciation was addressed in 22 out of the 50 documents (44%). However, many of the other 28 documents embedded the concept of speciation within standards concerned with natural selection. The following statements reflect ways speciation is emphasized as well as how speciation and natural selection are linked together.

- Describe how populations can change and new species arise through differential reproduction and survival of genotypes. (Maine)
- Explain the mechanisms by which new species arise. (Mississippi)
- Small differences between parents and offspring accumulate over many generations and ultimately new species may arise. (Delaware)
- New species may form when populations become isolated from each other. (Delaware)
- Mutation, natural selection, and reproductive isolation can lead to new species and explain the planet’s biodiversity. (Colorado)
- Explain how a new species or variety may originate through the evolutionary process of natural selection. (Michigan)
- . . . how new species emerge. (Virginia and South Dakota)

Descent with Modification

As change accumulates in species over the course of time, speciation occurs and new species share characteristics with other closely related species because of their shared ancestry. This process is described as descent with modification. Teaching About Evolution
and the Nature of Science (National Academy of Sciences, 1998, p. 42) states that “The confirmation of Darwin’s ideas about ‘descent with modification’ by this molecular evidence has been one of the most exciting developments in biology in this century.” Despite the centrality of this concept to the biological sciences and the growing evidence that supports this concept, only 21 of the 50 documents addressed the concept of descent with modification. Representative statements follow:

- Know that the theory of evolution explains how different species of plants, animals, and microorganisms that live on earth today are related by descent from common ancestors. (Idaho)
- Describe the theory of biological evolution which states that the earth’s present–day species are descended from earlier species. (Massachusetts)
- Use scientific evidence to demonstrate that descent from common ancestors produced today’s diversity of organisms over more than 3.5 billion years of evolution. (Arizona)
- The Earth’s present-day species evolved from earlier, distinctly different species. (Delaware)
- Molecular evidence substantiates the anatomical evidence for evolution and provides additional detail about the sequence in which various lines of descent branched off from one another. (Indiana)
- The degree of kinship between organisms or species can be estimated from the similarity of their DNA sequences, which often closely matches their classification based on anatomical similarities. (Indiana)
- Through evolution the earth’s present species developed from earlier distinctly different species. (New Jersey)
- Small differences between parents and offspring can accumulate (through selective breeding) in successive generations so that descendants are very different from their ancestors. (Rhode Island)

Evidence for Evolution

Despite the meager emphasis of evolution in biology textbooks during much of the twentieth century, evidence for evolution often would be included (Skoog, 1979, 1984). Thus it is somewhat surprising that only 38 of the 50 (76%) state frameworks address evidence of evolution. Representative standards follow:

- Understand how fossil, anatomical, molecular, and other observable forms of evidence provide support for the theory of natural selection. (Connecticut)
- Explain how scientific evidence from organic molecules (especially DNA), cells, fossils, comparative anatomy, and comparative embryology supports the idea that all forms of modern life have arisen from common ancestors. (Maine)
- Explore and describe molecular evidence that substantiates the anatomical evidence for evolution and provides additional detail about the sequence in which various lines of descent branched off from one another. (Massachusetts)
- Molecular evidence substantiates the anatomical evidence for evolution and provides additional detail about the sequence in which various lines of descent branched off from one another. (Rhode Island)
- The study of fossil records and living organisms provide evidence of the appearance, diversification, and extinction of many life forms. (Missouri)
- Identify evidence of change in species using fossils, DNA sequences, anatomical similarities, physiological similarities, and embryology. (Texas)
Pace and Direction of Evolution

Whereas there is little or no controversy among the scientific community about whether evolution occurs, there are unresolved questions about the pace (punctuated vs. gradual) of evolution. Also, there is a widespread perception among the public that evolution implies an improvement process whereby organisms become more and more complex, and, therefore “improved” over the ancestors. Fourteen of the 50 frameworks (28%) include a standard that specifically addresses the pace and/or direction of evolution. Among the standards, are the following:

- Changes in the types of species on Earth may have occurred either gradually or through sudden bursts of major change (punctuated equilibrium). (Connecticut)
- Understand evolution as a series of changes, some gradual and some sporadic, that account for present form and function of objects, organisms, and natural or technical systems. (Idaho)
- Evolution builds on what already exists, so the more variety there is, the more there can be in the future. But evolution does not necessitate long-term progress in some set direction. Evolutionary changes appear to be like the growth of a bush. Some branches survive from the beginning with little or no change, and others branch repeatedly, sometimes giving rise to more complex organisms. (Indiana)
- Examine and summarize evidence that evolution builds on what already exists, so the more variety there is, the more there can be in the future. But know that evolution does not necessitate long-term progress in some set direction. (Massachusetts)
- Evolution does not proceed at the same rate in all organisms; nor does it progress in some set direction. (Missouri)

Humans have Evolved Over Time

The National Science Education Standards, which provided the framework for this analysis, do not refer to human evolution. The standards of seven states (14%) refer to human evolution as follows:

- Fossil evidence is consistent with the idea that human beings evolved from earlier species and that the similarity of human DNA sequences and the resulting similarity in cell chemistry and anatomy identifies human beings as a single system. (Indiana)
- Describe what biologists consider to be evidence for human evolutionary relationships to selected animal groups. (Michigan)
- Educational experiences in grades 9–12 will assure that students describe the biological history of human beings. (Connecticut)
- Compare and contrast theories related to human evolution. (North Carolina)
- Explain the relationship of humans to other life forms and explain evidence that identifies all people as a single species. (Utah)
- Demonstrate knowledge of the nature of human origins and development. (North Carolina)
- Examine human history by describing the progression from early hominids to modern humans. (Pennsylvania)

Lerner’s study (2000, p. 24) identified standards in nine states that included human evolution explicitly and another nine by implication. As noted previously, this study included only those standards where it was evident that human evolution was to be the topic of study.
The infrequent appearance of standards related to human evolution provides evidence that the study of evolution continues to be influenced by antievolutionist pressures.

**Ambiguities**

Antievolutionists tend to incorrectly intertwine evolution and origins and use the terms interchangeably. Some of this confusion has seeped into state standards. Georgia standards indicate students should be able to describe and apply “concepts of origins” and explain “historical and current theories of origins (e.g., Big Bang, Evolution, and others)” (Georgia Department of Education, 1998). The introductory statement in Alabama’s standards also refers to origins and contains the following mandate:

> Explanations of the origin of life and major groups of plants and animals, including humans, shall be treated as theory and not as fact. When attempting to apply scientific knowledge to world problems, no social agenda shall be promoted (Alabama State Board of Education, 1995, p. 7).

In a somewhat obtuse manner, New Mexico 1996 standards, which were edited and strengthened in 1999, state “perform a critical scientific analysis of theories of biological origin based on direct observations, investigations, or historical data that accounts for the present form and function of objects, organisms, and natural systems” (New Mexico State Department of Education, 1996). In contrast, New Jersey standards clearly state that “All students will gain an understanding of the origin, evolution, and structure of the universe” (New Jersey Department of Education, 1998, Fall, p. 1). In an apparent effort to separate origins from evolution, Colorado’s standards state “This content standard does not define any student expectations related to the origin of life” (Colorado Department of Education, 1995, p. 18). Because of the tendency to confuse evolution and origins, Louisiana standards, which ask students to explore “experimental evidence that supports the theory of the origin of life” (Louisiana Department of Education, 1997, p. 38), and Maine’s, which asks students to “Analyze a theory scientists use to explain the origin of life” (Maine Department of Education, 1997) may be misinterpreted by some. Wisconsin’s standard that asks students to “Show how conflicting assumptions about science theories lead to different opinions and decisions about evolution, health, population and use of resources, and show how these opinions and decisions have diverse effects on an individual, a community, and a country, both now and in the future” (Wisconsin Department of Public Instruction, 1998, p. 59) is broader than the previous cited standards and seemingly designed to help students understand the importance and consequences of assumptions.

Critics of evolution often indicate that microevolution, which they define as change within a species, has occurred as in dogs, but that macroevolution, which they define as change from one species to another, has not occurred. Georgia standards in stipulating that students should compare “microevolution and macroevolution” (Georgia Department of Education, 1998) undoubtedly was influenced by these critics.

The word evolution or even the phrase “change over time” does not appear in the Mississippi standards for either biology I or II. Grade 8 standards stipulate that students “Investigate the diversity of life based on patterns of similarity and difference that occur in organisms” (Mississippi Department of Education, 1996, p. 99). An objective for biology I states “Explain the mechanisms by which new species arise” (p. 106). In Zoology, students are to “Compare life histories and developmental patterns exhibited by the different animal groups” (p. 164). The omission of the word evolution in Mississippi’s standard is not unusual as noted by Lerner (2000). However, the sparse treatment of evolution in these standards is not consistent with that of most other state standards.
The use of ambiguous language in textbooks and official state department of education documents has been commonplace during most of the twentieth century. Despite the examples cited here, the documents reviewed were refreshingly free of language that has been used historically to soften, hide, or neutralize text material concerned with evolution. Furthermore, standards derived from creationist tenets were nonexistent.

DISCUSSION

The metaphor “lever of change” is often used in the context of school reform. Metaphors are helpful in gaining an understanding of different concepts and phenomena. Metaphors both illuminate and limit. Will the science standards that address evolution act as a lever of change in impacting policy and instructional decisions? An affirmative answer suggests that decision-making processes and classrooms are characterized by linearity within a simple system where one change can result in a desired and proportional outcome. However, in political systems and classrooms where curriculum decisions constantly evolve and unfold over time, multiple factors interact and reinforce one another in response to both emerging contingencies and existing conditions. Educational change can not be reduced to a simple linear cause/effect situation. The change process involved is nonlinear and what comes out is not proportional to what goes in because of feedback loops that amplify small changes and other factors that complicate results. Because of this nonlinearity, responses to policy and curriculum decisions vary from teacher to teacher and, as a result, each classroom tends to be different.

Kennedy (1997) argued that teaching tends to remain relatively stable over time because it is difficult to do things differently in a classroom when the strategies being used solve so many problems and satisfy so many constraints. A small change in the routine of a classroom can grow exponentially and unravel an entire class period or day. Small, random events outside classrooms also can grow exponentially and impact teacher decisions more drastically than do policies and standards that are designed to bring about a desired result. So it is with evolution. For example, an edict (Moore, 1999) in a Louisiana community to glue textbook pages together so that pages describing the “big bang” theory will be unseen not only alters local classrooms but as news of this action spreads and is supplemented with other accounts of intimidation and suppression, the impact is magnified and spread over a larger area. The Scopes Trial created a chilling effect not only on teachers in Dayton, TN and those who taught in the 1920s but on teachers nationwide as this chill spread, persisted, and interacted with countless other minor and major episodes that combined to create conditions and teacher behavior that stifled the teaching of evolution in this nation in a significant manner for much of the twentieth century.

Systems can be changed and nudged towards a structure where desired outcomes will emerge. The intimidation of policymakers, administrators, teachers, and textbook publishers by antievolutionist pressures and actions that occurred with different level of intensity has been softened by a combination of significant changes and actions. Judicial rulings have stipulated that the teaching of evolution cannot be prohibited and that equal time mandates for creationism are unconstitutional. The Kansas State Board of Education 1999 decision to weaken and misrepresent the coverage of evolution in the state science standards was repudiated by the Kansas governor (Holden, 1999), the Kansas and nation’s press (Scott, 2000), and major science and science education organizations (American Association for the Advancement of Science, 1999) and eventually overturned by a newly constituted board that approved new standards that emphasized evolution (Beem, 2001). In the aftermath of the 1999 Kansas action, the New Mexico State Board of Education moved quickly to improve the coverage of evolution in the science standards when its existing document was
criticized for emphasizing evolution inadequately (Hoff, 1999; Wuethrich, 1999). In January 2000, the South Carolina Board of Education (2000, January) approved science standards that emphasized evolution in a comprehensive and honest manner. Public opposition to the actions of the New Mexico and South Carolina Boards was minor. The improved coverage of evolution in current high school biology textbooks provides additional evidence of change. In a recent poll, 83% of the respondents wanted evolution taught in the public schools (People for the American Way Foundation, 2000, March, p. 5). Finally, there is evidence that standard-based initiatives to improve schools are reaching into classrooms and gaining the support of teachers (Olson, 2001, p. 1). Because decisions about curriculum and instruction tend to be made locally and by teachers, this support is important. Also, standards that emphasize evolution also provide a shield of protection and support that is needed by teachers and administrators. Overall, these and other changes provide signals that the century-long struggle over evolution’s place in the nation’s science curricula has reached a significant and new stage.

Metaphorically speaking, evolution has been in the “eye of a storm” created and fueled by antievolutionists during the twentieth century. “Dark clouds” created by this storm have hung over the nation’s science classrooms and kept evolution from its rightful place in the curriculum. We think the science standards with their emphasis on evolution can be metaphorically depicted as “the sun moving from behind a dark cloud.” In light of the announcement of the sequencing of the human genome in February 2001 and the growing evidence of our common humanity and our likeness to other creatures, the lifting of this cloud was inevitable and necessary.

APPENDIX

TABLE A1
Detailed Analysis of Evolutionary Concepts Evident in State Science Standards

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<th>Species Change</th>
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*Science standards have not been developed.

### REFERENCES


ADDITIONAL WORKS CONSULTED IN THIS RESEARCH


