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Evolution in State Science Education Standards

Research Brief

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Science, Education, and Evolution

A large majority of scientists view the theory of biological evolution as accepted knowledge that has firmly withstood generations of empirical scrutiny and analysis. The core tenets of the theory are considered beyond serious dispute and represent a bedrock upon which the architecture of the modern life sciences have been built. Although a largely settled issue within scientific circles, encounters between evolution and the general public, politics, and the educational establishment in the United States have often been unsettling.

Starting most prominently with the fabled Scopes trial in 1925, critics of the theory have repeatedly opposed the teaching of evolution in the public schools. In a more contemporary example of such a challenge, between 1999 and 2001, the Kansas state board of education removed (and subsequently reinstated) references to biological evolution from the state's academic standards. In 2002, Ohio inserted language into its academic standards that effectively contests the scientific standing of evolution by calling on students to "describe how scientists continue to investigate and critically analyze aspects of evolutionary theory."

That passage from Ohio's standards is immediately qualified by a disclaimer noting that the preceding statement does not constitute a mandate to either teach or test on "intelligent design." This alternative explanation contends that certain biological processes and structures are so complex that they could not be a product of the mechanisms delineated by the theory of evolution. Intelligent design instead proposes that the development of life on Earth bears the mark of an outside designer or pre-existing intelligence. This counter explanation has gained currency among critics of evolution in recent years and lies at the heart of a federal trial currently under way in Harrisburg, Pa. In that proceeding, parents from the nearby town of Dover are seeking to overturn a school district policy that requires high school students to be introduced to the concept of intelligent design in addition to evolutionary theory.

Two approaching milestones in the federal No Child Left Behind Act related to science education have increasingly occupied the attention of the education and policy communities. Under the federal law, all states are required to have science education standards in place by the end of the 2005-06 school year. By the 2007-08 school year, states must also initiate annual assessments in science at the elementary, middle, and high school levels. In light of these developments, the academic content identified by states as core scientific knowledge for students to learn will soon carry even greater importance for the nation's schools.

This report describes the results of a systematic analysis of state science education standards conducted by the Editorial Projects in Education Research Center in conjunction with *Education Week*. We obtained information on the science education standards in 41 states from an extensive electronic database and devised a rigorous study methodology for analyzing the evolution content of those standards. In so doing, we were able to determine the extent to which the science standards in each state aligned with the treatment of evolutionary theory outlined in one influential and widely respected national standards document – *National Science Education Standards*, published by the National Research Council in 1996.

Our findings show that all of these state offer at least some minimal amount of attention to the theory of evolution or its attendant concepts, despite the fact that several states do not explicitly mention the word "evolution" in their standards. As described in detail below, considerable variation can be found in the extent to which different state standards capture key concepts related to evolution. Similarly, while certain basic aspects of evolution are covered by nearly all of these states, markedly fewer states' standards include statements pertaining to more subtle or potentially controversial elements of the theory.

Methodology

In this study, we perform a systematic and objective analysis of state academic standards in science education in order to characterize the extent to which these documents cover the theory of biological evolution. Studies of this kind typically adopt one of two general methodological approaches.

Some reviews of academic standards, for example, rely on an expert-driven process. Under this model, an individual reviewer (or team) with expertise in a particular content-knowledge area first develops a set of review criteria delineating concepts or features of interest. This rubric is then used to evaluate a series of standards documents in order to generate a score or grade for each set of standards. Expert-driven reviews of academic standards can provide very useful insights into the nature of content-knowledge expectations. If not carefully implemented, however, the results of such investigations can be swayed by the biases of the reviewers. The potential for bias can be minimized by taking such steps as providing explicit statements describing the study's conceptual orientation and its analytic rubrics or using multiple reviewers. When employing the latter measure, the issue of inter-rater reliability should also be taken into consideration.

In the present study, we have pursued an alternative approach to analyzing academic standards that might be described as a benchmarking strategy. This methodology starts by identifying an existing statement of academic content knowledge. This external standard then becomes a benchmark against which other sets of standards are compared. The objective here is to determine how closely a given set of standards aligns with the content of another particular document that serves as the benchmark. These types of studies are heavily reliant on the validity of the standards selected as the point of reference. Disputed or controversial benchmarks could call into question the results of such an investigation. For the present study, we have adopted the National Research Council's *National Science Education Standards* (*NSES*) as our objective benchmark. Highly respected within both scientific and educational communities, the *NSES* document outlines a vision of scientific literacy and includes standards describing what students should know and be able to do at particular grade levels.

From the *NSES*, we derive a set of concept statements describing core evolutionary principles. These benchmark concepts are then compared with the content of state-adopted academic standards in order to determine the extent to which the content in the states' standards aligns with the treatment of biological evolution in the *NSES*. As the following step-by-step description of the study methodology indicates, we utilize an extensive electronic database of academic standards and a standardized set of procedures and decision rules. These measures help to minimize the possibility that subjective judgments will affect the results of the analyses, thereby strengthening confidence in the findings.

Step 1:
Identifying Evolution Benchmark Concepts

Published in 1996, the *NSES* is a highly regarded and widely-cited statement of the content knowledge that students should be expected to learn in K-12 science education. In fact, a number of states have looked to this document as a model when developing their own academic standards in science. In consultation with outside experts in science and science education, we identified 10 statements from *NSES* that describe core concepts related to the theory of biological evolution. These statements, listed in Exhibit 1, span an array of topics that many experts would consider to reflect essential knowledge about evolution.

A potential critique that might be offered of this study lies in the choice of *NSES* as a point of reference for our analysis. For instance, it might be argued that another set of reference standards could have generated a different set of core evolution concepts and, therefore, different analytic results. Cognizant of this possibility, we also examined the treatment of evolution found in *Benchmarks for Science Literacy*, published by the American Association for the Advancement of Science (AAAS) in 1993. Like *NSES*, the AAAS document enjoys a strong reputation and has also been used as a guide in the development of state science standards. We found very close correspondence between the coverage of evolutionary theory in both *NSES* and *Benchmarks*. In fact, all 10 of the core evolution concepts from *NSES* examined in this study also appear in the AAAS document. This finding suggests that the results of our analysis are not unduly dependent on the choice of *NSES* as our benchmark, which provides validation for the methodology used in this study.

Step 2:
Linking Evolution Concepts to the Standards Database

The systematic analysis of evolution-content coverage performed in this study is made possible by an extensive database of academic standards documents maintained by Align to Achieve Inc. (A2A). This Standards Database comprehensively catalogs the content of science standards documents created by the states, the National Research

What is A2A? Align to Achieve, Inc., is an independent, not-for-profit organization created in October of 2001 as an outgrowth of its parent company, Achieve, Inc. One of the main purposes of Align to Achieve (A2A) is to build and maintain a Standards Database of the latest K-12 content standards and benchmarks from states, national organizations, and selected countries. For more information: www.aligntoachieve.org

EXHIBIT 1: EVOLUTION CONCEPTS FROM *NSES*

Evolution Concept Label	A2A Triplet Code	*NSES* Benchmark Language
Common ancestry of species	**4.3.4**	Millions of species of animals, plants, and microorganisms are alive today. Although different species might look dissimilar, the unity among organisms becomes apparent from an analysis of internal structures, the similarity of their chemical processes, and the evidence of common ancestry.
Classification systems reflect evolutionary relationships	**4.4.1**	Biological classifications are based on how organisms are related. Organisms are classified into a hierarchy of groups and subgroups based on similarities which reflect their evolutionary relationships. Species is the most fundamental unit of classification.
Variable effects of genetic change	**5.4.4**	Changes in DNA (mutations) occur spontaneously at low rates. Some of these changes make no difference to the organism, whereas others can change cells and organisms. Only mutations in germ cells can create the variation that changes an organism's offspring.
Fossil record reflects changing life forms	**9.3.1**	Fossils indicate that many organisms that lived long ago are extinct. Extinction of species is common; most of the species that have lived on the earth no longer exist.
Biological adaptation and survival	**9.3.2**	Biological evolution accounts for the diversity of species developed through gradual processes over many generations. Species acquire many of their unique characteristics through biological adaptation, which involves the selection of naturally occurring variations in populations. Biological adaptations include changes in structures, behaviors, or physiology that enhance survival and reproductive success in a particular environment.
Changes in the environment	**9.3.3**	Extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient to allow its survival.
Natural selection	**9.4.2**	Like other aspects of an organism's biology, behaviors have evolved through natural selection. Behaviors often have an adaptive logic when viewed in terms of evolutionary principles.
Similarity among diverse species	**9.4.3**	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 living organisms.
Mechanisms of evolution	**9.4.4**	Species evolve over time. Evolution is the consequence of the interactions of (1) the potential for a species to increase its numbers, (2) the genetic variability of offspring due to mutation and recombination of genes, (3) a finite supply of the resources required for life, and (4) the ensuing selection by the environment of those offspring better able to survive and leave offspring.
Timeframe of biological evolution	**9.4.5**	The great diversity of organisms is the result of more than 3.5 billion years of evolution that has filled every available niche with life forms.

Council (i.e., *NSES*), and several other professional organizations (e.g., AAAS). Every set of standards contained in the database has been divided into numerous (typically several hundred) individual entries, each of which contains a discrete standard, benchmark, or statement of scientific-content knowledge. Some state standards present content knowledge in outline form while others describe this content using more extended passages of prose. So depending on the ways in which a particular standards documents is organized, database entries can range in length from a short phrase to an entire paragraph.

Entries in the A2A database are organized using a heuristic tool known as the "Compendix," an extensive index of distinct scientific concepts, each of which is identified by a unique three-part code known as a "triplet." The triplet system of the Compendix catalogs scientific concepts in much the same way as the Dewey Decimal system would be used to catalog holdings in a library collection. In addition to its focal statement of academic-content knowledge, each Compendix entry also provides a set of vocabulary terms related to that particular concept.

When benchmark statements derived from a standards document (e.g. *NSES* or a state's academic standards) are added to the Standards Database, each entry is assigned a triplet code that refers to the corresponding scientific concept from the Compendix. The state benchmark is also indexed using a subset of relevant concept vocabulary terms. A database entry might be indexed against more than one Compendix triplet code if the standard statement captures multiple concepts (a common occurrence with longer entries). For the purposes of illustration, Exhibit 2 depicts an A2A database entry from *NSES* related to evolution. The first portion of the entry contains the content of the benchmark statement as it appears in the *NSES* document. The second part of the entry describes the Compendix benchmark that corresponds to this evolution principle (including the triplet key, Compendix text, and related concept vocabulary).

As the description above suggests, the Compendix is the common language of the A2A database and the device used to systematically catalog the multitude of entries from state and professional standards documents. The triplet codes can also be used to perform a crosswalk. That is, we can align the content captured across multiple sets of standards by means of their shared triplet codes. The first step in this crosswalk process involves identifying the Compendix triplet codes assigned to the 10 *NSES* concept statements on evolution. This was accomplished using the publicly accessible database search on the Align to Achieve Web site. For reference purposes, Exhibit 1 above lists the triplet codes corresponding to the focal evolution concepts. Using these triplets, we can proceed with the two-stage electronic search process that will enable us to identify the state standards or benchmarks corresponding to these evolution concepts from *NSES*.

EXHIBIT 2: SAMPLE A2A DATABASE ENTRY

National Science Education Standards (NSES) Grade: 9 - 12 Science

Life Science
Content Standard C:
As a result of their activities in grades 9-12, all students should develop understanding of
- The cell
- Molecular basis of heredity
- Biological evolution
- Interdependence of organisms
- Matter, energy, and organization in living systems
- Behavior of organisms
Biological Evolution

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 living organisms.

Achieve+McREL Standards Catalog Alignment

Subject	Benchmark Key	Benchmark with Concept Vocabulary
Science	9.4.3	Knows how natural selection and its evolutionary consequences provide a scientific explanation for the diversity and unity of past and present life forms on Earth (e.g., recurring patterns of relationship exist throughout the fossil record; molecular similarities exist among the diverse species of living organisms; the millions of different species living today appear to be related by descent from common ancestors) A. natural selection, B. biological evolution, E. prehistoric life forms, G. fossil record, H. species similarity, I. organism, M. molecular similarity

Step 3:
Triplet Search of the A2A Database

As mentioned previously, the A2A Standards Database systematically catalogs academic standards that have been adopted by the states or published by professional organizations in four core-subject areas. It should be noted that the database does not contain draft versions of state standards or supplementary documents such as curricular guides that have not been officially adopted as standards by the appropriate state authority (e.g., board of education or legislature). At present, the database houses K-12 science education standards from 41 states, in addition to *NSES* and the AAAS *Benchmarks* documents.

State academic standards themselves are in a nearly constant state of evolution, with revised documents periodically adopted to replace earlier versions. This reality of the standards-development and -adoption process has two implications for the present study. First, there are several instances where the A2A database contains multiple documents for a given state, representing different revisions of the standards adopted at different points in time. When such a situation was encountered, we selected the more recent version of the standards for analysis. Second, it is possible that the science standards available for a given state in the A2A database could have been superseded by a more recent version. In light of approaching No Child Left Behind mandates, it is also reasonable to anticipate a major wave of state revisions and adoptions for science standards in the near future.

Although keeping up-to-date in a rapidly changing field can be extraordinarily difficult, we can at least provide the reader with additional information about the standards documents analyzed for this study. Exhibit 3 lists the title of each of these standards documents, along with the year in which those standards were adopted by the state.

EXHIBIT 3: STANDARDS REVIEWED		
Alabama	2001	Alabama Course of Study: Science
Arizona	1997	Arizona Academic Standards: Science
Arkansas	1999	Arkansas Science Curriculum Frameworks Revised 1999
California	1998	Science Content Standards for California Public Schools, Kindergarten Through Grade Twelve
Colorado	1995	Colorado Model Content Standards for Science
Florida	1999	Grade Level Expectations for the Sunshine State Standards: Science
Georgia	2004	Georgia Science Performance Standards
Hawaii	1999	Hawai'i Science Content Standards
Idaho	2001	Idaho Achievement Standards K-12 in Science
Illinois	1997	Illinois Learning Standards for Science
Indiana	2000	Indiana's Academic Standards 2000 for K-12 Science
Kansas	2001	Kansas Science Education Standards
Kentucky	1998	Kentucky Science (Primary, Intermediate, High School)
Louisiana	2003	Louisiana Science Grade-Level Expectations
Maine	1997	Learning Results for Science and Technology
Maryland	2000	Maryland State Content Standards for Science
Massachusetts	2001	Massachusetts Science and Technology/Engineering Curriculum Framework
Michigan	2000	Michigan Curriculum Framework Science Benchmarks
Minnesota	2004	Minnesota Academic Standards Science K-12
Mississippi	2001	Mississippi Science Framework
Montana	1999	Montana Standards for Science
Nebraska	1998	Nebraska Science Standards
Nevada	1998	Nevada Science Content Standards for Grades 2, 3, 5, 8, and 12 and Grade Level Indicators for Kindergarten and Grades 1, 4, 6 and 7
New Hampshire	1995	K-12 Science Curriculum Framework
New Jersey	1998	New Jersey Core Curriculum Content Standards for Science
New Mexico	2003	New Mexico Science Content Standards, Benchmarks, and Performance Standards
New York	1996	Learning Standards for Mathematics, Science, and Technology
North Carolina	2004	North Carolina Science Standard Course of Study and Grade Level Competencies
North Dakota	2002	North Dakota Science Content Standards and Benchmarks
Ohio	2002	Ohio Science Academic Content Standards
Oklahoma	2002	Oklahoma's Priority Academic Student Skills (PASS) for Science
Rhode Island	1995	Science Literacy for ALL Students: The Rhode Island State Science Framework
South Dakota	1999	South Dakota Science Standards
Tennessee	2001	Tennessee Science Curriculum Standards
Texas	1997	Chapter 112. Texas Essential Knowledge and Skills for Science
Utah	2002	Utah K-6 Elementary Science Core Curriculum; 2003 Utah Secondary Science Core Curriculum
Vermont	2000	Vermont's 2000 Framework of Standards and Learning Opportunities
Virginia	2003	Science Standards of Learning for Virginia Public Schools
Washington	1998	The Essential Academic Learning Requirements in Science
Wisconsin	1998	Wisconsin Model Academic Standards for Science
Wyoming	2003	Wyoming Science Content and Performance Standards

Align to Achieve offers a variety of online-search functions that can be utilized to explore the standards database. Two separate search processes were employed in the present study.

In the first stage, we performed an electronic search to identify state standard entries that were assigned one of the Compendix triplets corresponding to the 10 core evolution concepts from *NSES*. So in effect, 410 separate queries were performed – one for each of the 10 triplet codes in each of the 41 states with standards in the A2A database. To facilitate this process, Align to Achieve provided the researchers with access to an administrative database.

For a given state and triplet, this query could generate multiple "hits" (cataloged statements indexed against the triplet), one hit, or no hits. It should be noted that the indexing of entries in the A2A database by triplet codes is concept-dependent, not vocabulary-dependent. So a state need not use the same terminology as *NSES* (or the Compendix) to describe a particular evolution concept in order to generate a hit in this search.

Step 4:
Keyword Search of the A2A Database

The A2A Standards Database was constructed by analysts who reviewed state (and other) standards documents, subdivided these documents into discrete benchmark-sized entries, and indexed each entry using one or more Compendix triplet codes and a set of concept vocabulary terms. Particularly when entries contain compound statements capturing multiple closely-related concepts, the matter of indexing a particular entry may not be entirely straightforward. In order to accommodate any possible ambiguity that might have arisen in the indexing of standards as the database was being compiled, we performed a secondary search to complement the triplet-based search described above.

This second query involved a keyword search of the A2A database. For each of the 10 focal evolution concepts, we identified from one to three key terms or phrases related to that particular aspect of evolutionary theory. Exhibit 4 lists these keyword search terms, with the underlined portion of the term representing the exact search string used. Like the initial triplet search, this procedure generated a set of hits – state benchmarks containing the relevant keyword term. The hits from the two search stages were then pooled together for further examination in the final stage of our analysis.

Step 5:
Vetting "Hits" from Electronic Searches to Identify "Matches"

Mechanistic search processes, such as those described above, are useful to the extent that they provide a way to conduct an automated, systematic query. However, such searches are also necessarily limited by the functional parameters of the search engine and the organization of the underlying database. As a result, it is possible – often inevitable – that some false hits will be generated. For instance, the Compendix index that organizes the A2A Standards Database often consists of statements that are more extensive than those appearing in the *NSES* or state benchmark entries. A Compendix statement related to evolution could, therefore, be cataloged according to multiple elements or subconcepts. Not all of these subconcepts will be relevant for our analysis.

Consequently, it is necessary to vet each individual hit from the electronic searches in order to determine whether it matches the evolution concept actually being targeted. A vetting rule or guideline was developed and applied for each of the 10 focal evolution concepts. These rules (reported in Exhibit 4) provide a transparent and uniform method for determining whether a mechanical "hit" generated by our search actually constitutes a "match" in terms of the content of the statement.

SUMMARY OF FINDINGS

Using the methodology described above, we performed an alignment analysis focusing on the evolution content of science education standards. That is, we determined the extent to which the science standards of a particular state captured the 10 core evolution concepts derived from *NSES*.

EXHIBIT 4: SEARCH AND VETTING CRITERIA

Evolution Concept Label	A2A Triplet	Keyword Search Terms	Vetting Guidelines
Common ancestry of species	**4.3.4**	evolutionary relationship common ancestry kinship	Benchmark notes common ancestry or evolutionary relationships among species (which may display surface dissimilarities).
Classification systems reflect evolutionary relationships	**4.4.1**	classification evolutionary relationship	Benchmark makes connection between biological classification systems and the evolutionary relationships among species. Link to classification can also be described in terms of degree of kinship, common descent, or common ancestry of species.
Variable effects of genetic change	**5.4.4**	value of characteristic mutation genetic change	Benchmark describes that genetic changes can have variable effects that relate to organism or species success.
Fossil record reflects changing life forms	**9.3.1**	fossil	Benchmark references the fossil record and changes in life forms over time (e.g., extinction, emergence of new species, or diversification of life).
Biological adaptation and survival	**9.3.2**	biological adaptation survival	Benchmark cites biological adaptation or survival. Benchmark does not need to mention evolution explicitly to receive credit.
Changes in environment	**9.3.3**	extinction environment survival	Benchmark relates changes in the environment to the process of extinction, survival, or adaptation.
Natural selection	**9.4.2**	natural selection	Benchmark references or describes natural selection. Credit for match awarded even for brief reference or citation of term "natural selection."
Similarity among diverse species	**9.4.3**	diversity similarity common descent	Benchmark establishes clear connection between evolution and similarities among species.
Mechanisms of evolution	**9.4.4**	natural selection	Benchmark explicitly elaborates on the theory of evolution by citing or describing relevant mechanisms related to natural selection (e.g., environmental pressures, variation within species, adaptation, survival). At least one such mechanism must be cited. Credit not awarded for simply citing the term "natural selection."
Timeframe of biological evolution	**9.4.5**	billion	Benchmark explicitly describes the time of the evolution of life forms as occurring over billions of years.

A detailed state-by-concept table presenting the results of our analysis appears in Exhibit 5. States are ranked by alignment score, indicating the number of *NSES*-derived evolution concepts covered in their respective standards.

We find that all of the 41 state standards examined in this analysis contain some content related to the theory of biological evolution. That is, each set of state standards contains language that aligns with at least one of the focal evolution concepts. Based on these results, we can conclude that none of these states completely excludes the topic of evolution from their standards. However, despite the fact that most experts consider evolution theory to be an essential element of science education, our findings reveal a

EXHIBIT 5: RESULTS OF ALIGNMENT ANALYSIS

	Common ancestry 4.3.4	Classification systems 4.4.1	Genetic change 5.4.4	Fossil record 9.3.1	Biological adaptation 9.3.2	Changes in environment 9.3.3	Natural selection 9.4.2	Species similarity 9.4.3	Evolution mechanisms 9.4.4	Evolution timeframe 9.4.5	**Alignment Score (0-10)**
Arizona	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	**10**
Indiana	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	**10**
New Mexico	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	**10**
Ohio	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	**10**
California		✓	✓	✓	✓	✓	✓	✓	✓	✓	**9**
Idaho	✓	✓	✓	✓	✓	✓	✓	✓	✓		**9**
Minnesota	✓	✓	✓	✓	✓	✓	✓	✓	✓		**9**
Nebraska	✓	✓	✓	✓	✓	✓	✓	✓	✓		**9**
Nevada	✓	✓		✓	✓	✓	✓	✓	✓	✓	**9**
Rhode Island	✓	✓	✓	✓	✓	✓	✓	✓	✓		**9**
Utah	✓	✓	✓	✓	✓	✓	✓	✓	✓		**9**
Alabama		✓	✓	✓	✓	✓	✓	✓	✓		**8**
Wyoming	✓	✓	✓	✓	✓		✓	✓	✓		**8**
Colorado			✓	✓	✓	✓	✓	✓	✓		**7**
Florida			✓	✓	✓	✓	✓	✓	✓		**7**
Georgia	✓	✓		✓	✓	✓	✓		✓		**7**
Maryland		✓	✓	✓	✓	✓	✓		✓		**7**
Michigan	✓			✓	✓	✓	✓	✓	✓		**7**
North Carolina	✓	✓		✓	✓	✓	✓	✓			**7**
Arkansas			✓		✓	✓	✓	✓	✓		**6**
Kansas	✓				✓	✓	✓	✓	✓		**6**
Maine	✓		✓	✓	✓	✓	✓				**6**
Mississippi				✓	✓	✓	✓	✓	✓		**6**
Tennessee		✓	✓	✓	✓	✓	✓				**6**
Texas			✓	✓	✓	✓	✓	✓			**6**
Vermont	✓	✓		✓	✓		✓	✓			**6**
Massachusetts			✓	✓	✓	✓	✓				**5**
New Hampshire	✓	✓			✓		✓	✓			**5**
New Jersey	✓			✓	✓	✓	✓				**5**
Oklahoma	✓			✓	✓	✓		✓			**5**
South Dakota			✓	✓	✓	✓	✓				**5**
Virginia				✓	✓	✓	✓		✓		**5**
Hawaii				✓		✓	✓	✓			**4**
Louisiana		✓		✓	✓	✓					**4**
Washington				✓	✓		✓	✓			**4**
Wisconsin		✓			✓		✓	✓			**4**
Illinois				✓	✓	✓					**3**
Kentucky				✓	✓						**2**
Montana		✓					✓				**2**
New York					✓						**1**
North Dakota					✓						**1**

tremendous range in the extent of coverage that the various state standards afford to this topic.

No state scored a zero. However, the number of concepts reflected in the state standards ranges from a low of one to a high of 10. In the two states at the low end of the spectrum (New York, North Dakota), for example, coverage of evolution is limited to a single topic – the process of biological adaptation as it pertains to the survival of organisms and reproductive success. Another pair of states score matches for only two concepts. Standards in Kentucky likewise address the subject of adaptation, along with fossil-record evidence for evolution. In Montana, standards reference natural selection and the evolutionary relationships that underlie biological-classification systems.

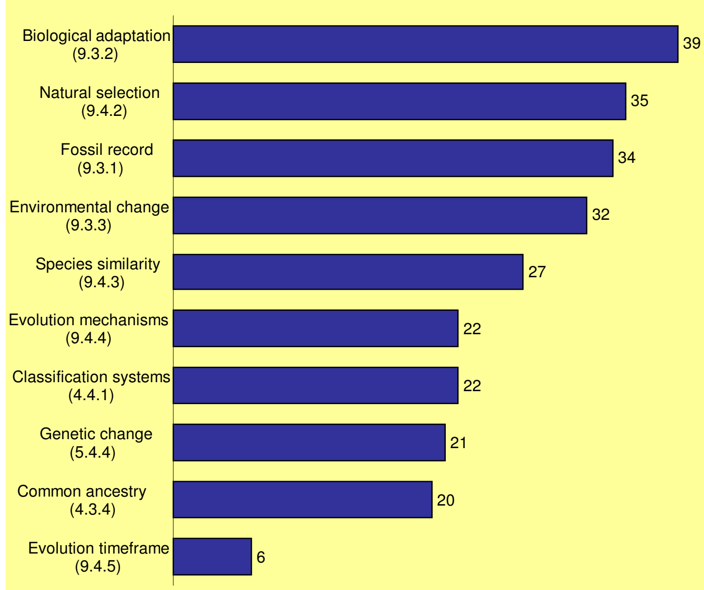
At the opposite end of the scale, a "perfect" alignment score was received by four states – Arizona, Indiana, New Mexico, and Ohio. The science standards in these states capture all 10 of the focal evolutionary concepts. Most states, of course, fall somewhere between these extremes. In the average state, science education standards cover just over half (six) of the core topics identified from the *NSES*.

The particular combination of concepts covered by the states displays some variation, even among those receiving similar scores. An examination of the results reveals some interesting patterns (see Exhibit 6). For instance, some evolution concepts are covered in nearly all states, while others are included in the standards of only a handful of states. Among the evolution concepts examined, the topic of biological adaptation (triplet 9.3.2) was the most frequently encountered, appearing in the science standards of 39 out of 41 states analyzed. Over 30 states also provided some treatment of three other core concepts: natural selection as a key element of evolutionary theory (9.4.2); the fossil record as evidence of changing and evolving life forms (9.3.1); and the connection between environmental changes and the survival of species (9.3.3).

By contrast, fewer than half of the 41 state standards noted that evolution provides a basis for understanding that the common ancestry of different species accounts for their underlying similarities (4.3.4). Only six state science standards documents concretely describe the timeframe over which life forms have been shaped by evolution, a period of roughly 3.5 billion years. It should be added that some states offered vaguer references to evolution occurring over a "long" period of time, which our analysis did not credit as a match with the *NSES* standard. These latter findings are noteworthy because the age of the Earth and the length of time life has existed have been points of contention between proponents of evolutionary theory and "young earth" creationists. The latter adhere to a literal interpretation of the Bible, which would place the age of the Earth at about 6,000 years.

A separate keyword analysis was performed to determine whether states use the term "evolution" in the context of describing the biological process of change in organisms and species over time. This particular usage of the term is intended to distinguish statements related to the biological theory of evolution from those describing the history of the universe or geological processes. A number of states also employ the term "evolution" in the latter context. We found that only four states among the 41 analyzed did not mention the word "evolution" (or a related form such as "evolve") in their standards: Florida, Illinois, Kentucky, and Oklahoma. In place of the term "evolution," the standards in these states typically substituted an alternative word or phrase, such as "changes over time," "diversity of species," or "genetic diversity." Two of these states (Florida, Oklahoma) nevertheless received alignment scores in the average range (7 and 5 respectively), despite the fact that their standards do not mention the word "evolution."

Exhibit 6: States With Aligned Benchmark (out of 41)



This finding underscores an important methodological point mentioned earlier. Namely, the procedures used to catalog in the A2A database are not heavily dependent on the use of specific terminology. The critical factor underlying the state alignment scores is simply the representation of the respective evolution concept within the standards documents, in some form or another. In most cases, credit could be earned for having an aligned concept even by a very briefly worded state benchmark, provided that the relevant concept or term was cited in the appropriate context. Therefore, the methodology applied in this study does not inherently discriminate between outline-style standards that consist of short statements (sometimes a single word or phrase) and standards organized around longer passages of text.

CONCLUSION

This study offers one perspective on a critical but complex educational issue. Indeed, the teaching of evolution has often sparked controversy and has repeatedly become entangled in heavily politicized disputes. The current investigation should be viewed as a first step down a fruitful avenue along which researchers can continue to investigate the ways in which the theory of biological evolution has been incorporated in state science education standards. It would be interesting, for example, for analysts to return to this issue again once the states have implemented or revised their science standards as required by the federal NCLB legislation.

The present study has been careful to avoid making normative or qualitative statements about the treatment of evolution in state standards. We have assessed whether or not states address particular intellectual components of evolutionary theory in their standards. But we have offered no speculation as to whether, in a more subjective sense, a particular state's coverage of these topics is either good or bad, adequate or inadequate, exemplary or disgraceful. To an analyst concerned with making such judgments, examples of all of the above could be found among the various state standards.

This observation raises a final issue that is worth mentioning briefly in closing. The alignment score received by a given state's standards in this study does not necessarily reflect a deliberate attempt by the state to deal with the topic of biological evolution in a more or less thorough manner than other scientific principles. Some states have created highly skeletal standards documents in which scientific concepts are essentially listed like vocabulary words. In such cases, no individual issue receives in-depth treatment. By contrast, other states provide substantive explications of the ideas associated with evolution as well as a variety of other central issues in science. So it is important to reiterate that a low alignment score should not be interpreted as an intentional attempt to slight the theory of evolution. Evolution may very well receive equal (if brief) treatment compared with other topics.

There is, however, a broader issue to contemplate in this regard. Namely, one may ask to what extent any set of standards that treats expectations for important scientific knowledge in a highly abbreviated manner can serve as a useful touchstone for the stakeholders in our public schools – the educators who need to develop curricula and instructional strategies, parents who want to know what their children are expected to learn in school, and the public whose well-being in a society that grows more technologically sophisticated by the day will depend on the level of science literacy attained by the next generation.

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