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Aligning science standards: Arkansas and the 2009 National Assessment of Educational Progress (NAEP)

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July 2007

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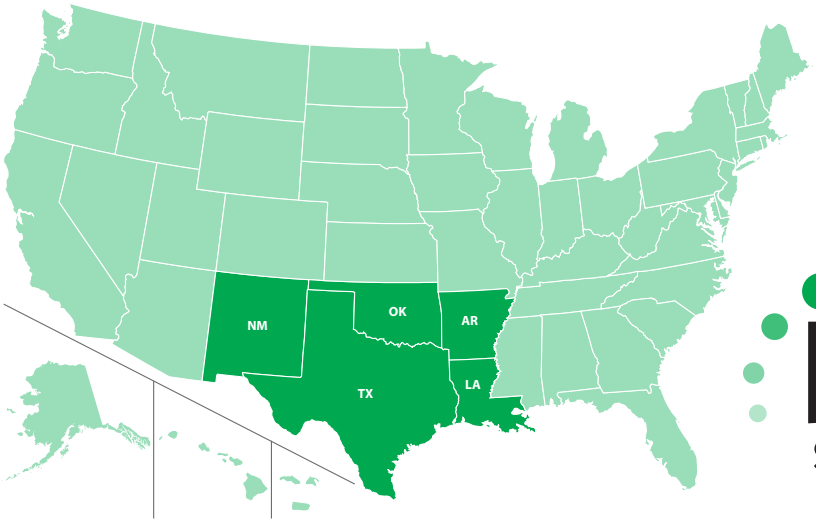

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July 2007

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This report is available on the regional educational laboratory web site at http://ies.ed.gov/ncee/edlabs.

Summary

Aligning science standards: Arkansas and the 2009 National Assessment of Educational Progress (NAEP)

This policy research document is intended for Arkansas policymakers to use when examining possible changes to the Arkansas state assessment's alignment with the National Assessment of Educational Progress (NAEP). The 2009 NAEP test is not yet in existence, so the purpose of this report is to give policymakers a headstart in determining where they might, if they so decide, begin to make changes in their assessment standards and create test specifications to develop an assessment system more closely aligned with that used for the NAEP.

This report reveals alignment issues between the state's tests and future NAEP tests and may be especially important to those considering revising their science standards and assessments in line with No Child Left Behind requirements for state science tests in elementary, middle, and high schools. Revising assessments requires considerable time and resources, so policymakers must carefully consider their capacity for making changes and the degree to which such changes will benefit students.

The analysis here uses the Arkansas Science Curriculum Frameworks for grades K–8 and for biology. The NAEP is administered to students in grades 4, 8, and 12, but Arkansas conducts statewide tests in grade 5, grade 7, and biology. Since the Arkansas standards for grade 5, grade 7, and biology were most likely to appear on state assessments, they were used to compare Arkansas standards with the NAEP standards.

This study was designed to compare the NAEP and a corresponding state assessment framework. However, science specialists in Arkansas indicated that their statewide exams draw from the entire set of standards within the Science Curriculum Frameworks and thus this alignment was performed with the NAEP, which is an "assessment framework," and the Arkansas Science Curriculum Frameworks, which are designed to indicate what science should be taught at various grade levels.

Grade 4 alignment

Nearly all NAEP grade 4 content items are to some degree addressed by the Arkansas science framework, but the Arkansas statements typically are only partially aligned with NAEP statements and often are not found at the Arkansas grade 5 level. Most of the Arkansas grade 5 learning expectations go beyond the content covered by the NAEP. But most NAEP content is partially aligned with Arkansas content at grade levels above and below fifth grade. The overall alignment rating for NAEP

grade 4 standards and grade 5 Arkansas standards was 2.0—partial alignment. (A rating of 1 indicates no alignment, and a rating of 3, full alignment.)

Grade 8 alignment

The majority of NAEP grade 8 content statements are partially aligned with the content found within the Arkansas Science Curriculum Framework. Most statements were given ratings of 2 because NAEP standards typically contain more detail than the corresponding Arkansas standards. More than half of Arkansas grade 7 science standards in the curriculum framework are unaddressed by the NAEP, most likely because the alignment was performed between the NAEP's more specific content areas—designed for use on an assessment—and Arkansas's more wide-ranging content areas—from its curriculum framework. The overall alignment rating when comparing the Arkansas Science Curriculum Framework to NAEP's grade 8 content statements was 2.1—partial alignment.

Grade 12 alignment

Arkansas biology learning expectations are moderately aligned with NAEP's life science standards—all NAEP statements are at least partially addressed by Arkansas standards. Arkansas statements mostly imply the content explicitly stated by the NAEP. The overall alignment rating for NAEP life science was 2.1.

Test specifications

Standards and test specifications are the starting point for developing tests and test items. In the ideal alignment study state science assessments would be directly compared with NAEP assessments at the item level. The NAEP 2009 assessment items may someday be available for such a study. Since the purpose of this report is to allow policymakers to examine their alignment with NAEP before the test is implemented, no further research is suggested.

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This policy research document is intended for policymakers to use when examining possible changes to the Arkansas state assessment's alignment with the National Assessment of Educational Progress (NAEP).

BACKGROUND TO THE STUDY

This report presents the findings of an alignment study comparing the new science framework for the 2009 NAEP and its accompanying Science Assessment and Item Specifications with the Arkansas state science assessment. More details about the documents compared are in appendix A. The study was conducted for the Regional Education Laboratory Southwest, funded by the Institute of Education Sciences, to provide research and support to Arkansas, Louisiana, New Mexico, Oklahoma, and Texas. The study was undertaken in anticipation of a growing need in the region to be better informed about how state assessment standards in science compare with those tested in the NAEP.

The 2009 NAEP test is not yet in existence, so the purpose of this report is to give policymakers a headstart in determining where they might, if they so decide, begin to make changes in their assessment standards and create test specifications to develop an assessment system more closely aligned with that used for the NAEP.

Five factors make this alignment study timely. First, the importance of state science assessments has been increased by the No Child Left Behind Act of 2001. Beginning in the 2007/08 school year, states are required to administer science assessments to all students in each of the elementary, middle, and high school levels, holding states and local school districts accountable for student academic achievement in science (NCLB, 2001).

Second, the NAEP is increasingly being used as a benchmark against which student achievement across the nation can be compared (Linn, 2005; Linn, Baker & Herman, 2005). The NAEP has been dubbed the "nation's report card," and when fresh NAEP results are released—as they were for science in 2006, following an administration of the test in 2005—the media report the results (Cavanagh, 2006a, 2006b). Although states are not sanctioned for failing to demonstrate NAEP student performance improvement, NAEP data do provide an external accountability benchmark and serve to verify student achievement on state assessments. In fact, the National Center for Education Statistics has a website (http://nces.ed.gov/nationsreportcard/nde/statecomp/) that allows anyone to create customized comparative reports based on the latest NAEP data. So anyone can create tables that compare states and jurisdictions based on the average scale scores for selected groups of public school students within a single assessment year, or compare the change in performance between two assessment years.

Third, NAEP data are being used more in education research to investigate how the No Child Left Behind Act provisions have played out in different states. For example, Olson (2005) compared the percentages of students at or above the proficient level on the 2005 state grade 8 mathematics assessments in 33 states. The study showed that, on average, 33 percent more students scored at the proficient level or above according to the state assessment than did so according to the NAEP. As yet, no similar study has been done of science, but with the release of the 2005 NAEP results it is now possible to do so.

Fourth, political attention is beginning to focus on using the NAEP as a yardstick for measuring state standards (Olson, 2007). In January 2007 two bills were introduced in Congress, one seeking to encourage states to benchmark their own standards and tests to NAEP and the other calling for states to adopt voluntary "American education content standards" in mathematics and science that would be developed by the National Assessment Governing Board, the body responsible for the NAEP. These issues will doubtless be a topic of debate in the upcoming reauthorization of the No Child Left Behind Act.

Fifth, the standards and test specifications that form the blueprint for the content the NAEP science assessment covers and the types of items it uses were revised. In 2006 the 2009 NAEP framework takes account of the latest knowledge on science learning and assessment, which suggests that measuring student understanding involves much more than assessing factual knowledge. It defines the science knowledge and skills that science-literate students should possess at grades 4, 8, and 12. The assessment itself, while retaining some familiar paper and pencil assessment formats, will also include student performance assessments in both classroom settings and computer simulations. The 2009 NAEP framework will determine the shape of NAEP science assessments through 2017, setting the direction of science assessment across the nation.

Several factors are working together to raise the National Assessment of Educational Progress to a de facto national benchmark, and states want to know how well their state standards align with it

These factors are working together to gradually raise the NAEP to a de facto national benchmark, and states naturally want to know how well their state standards align with the NAEP so they can make informed decisions about possible changes to their own standards and assessment systems. This report describes the results of a systematic alignment study conducted for that purpose. Details of the study are in appendix B.

The intent of this report is to inform those in the Arkansas Department of Education who are responsible for shaping the state assessment in science how the current assessment standards compare with those of the NAEP 2009 assessment.

Similar reports have been completed for Louisiana, New Mexico, Oklahoma, and Texas, but there is no intent to compare Arkansas with these states. The audience of this report is solely those in the Arkansas Department of Education who are interested in the state's alignment with NAEP 2009 science standards. This report shows where there is good content alignment with NAEP standards, identifies where there is partial alignment, pinpoints NAEP standards where there are no corresponding state standards, and highlights where the Arkansas standards go beyond the NAEP. The reports on the other Southwest Region states also deal with the assessment specifications, showing what percentages of the NAEP assessment at each grade level are devoted to different science topics and comparing that to the coverage of the topics in the states' assessments. However, this report differs in that it does not include an analysis of test specifications because they were not readily available and in that it uses the state's curriculum standards because Arkansas state science specialists do not have a separate set of assessment standards as other states do.

The results are presented in summary in the tables and narratives in the sections that follow. Those sections provide an analysis that highlights the differences found between the NAEP assessment and the Arkansas state assessment. For more detail about the alignment of the Arkansas curriculum standards to the individual content statements of the NAEP, turn to the tables in appendixes C–E. They show exactly which Arkansas standards align with a particular NAEP statement and, in cases of partial alignment, explain why. For a discussion of methodology, see box 1 and appendix B.

CONTENT ALIGNMENT AT GRADE 4

The NAEP grade 4 science standards were compared with the Arkansas Science Curriculum Framework primarily at grade 5, which is when Arkansas gives its elementary science benchmark tests. Arkansas recommended using its Science Curriculum Framework for this study because all assessment content was drawn from standards within the curriculum framework. Thus, while the alignments performed with other states in the Southwest Region were completed using only the subset of curriculum content found within

BOX 1

Methodology

The chief research question driving this study was "To what extent do current state assessment standards cover the content on which NAEP 2009 assessments will be based?" This question was addressed using curriculum standards instead of assessment standards because the Arkansas state science specialists indicated that all curriculum standards were used for test development and no subset of "assessment standards" was available. The studies for the other Southwest Region states address the question "To what extent do current state assessment specifications align with the NAEP 2009 assessment specifications?" but there were no science assessment specifications readily available for use in the study for Arkansas.

The methodology used to answer the chief research question followed the successful pattern of a similar study conducted by WestEd in New England, which examined the alignment of math and reading standards with the NAEP. The methodology developed by WestEd for the New England study was designed to include all the most prominent alignment methodologies, discussed in appendix B. Thus far, alignment studies and methods have focused on aligning standards and tests, whereas the objective of this study was to compare one set of assessment standards and specifications with another. The methodology in this study, however, is based upon methodologies for aligning standards to tests, because similar principles are used in both types of alignments.

In this study reviewers followed the methodology of the portion of the previous study examining alignment between two sets of standards. Reviewers performed gap analyses to identify content included in one set of standards but not the other, identified issues of order so they could reveal differences in the grade levels at which standards appear, and examined the degree to which the standards and assessments cover content to the same depth and have similar cognitive demands (depth-of-knowledge) and the degree to which assessments cover the same range of content as the corresponding standards (range-of-knowledge correspondence) to determine whether there was a match between Arkansas and NAEP in the level of detail, the cognitive demands, and the range of content covered. A coding scheme (similar to that of the Buros Center) was used to indicate alignment issues and reviewer ratings, and a matrix-like format (similar to Porter's method) was created to facilitate alignment (see appendix B).

Reviewers attended several training sessions, conducted individual reviews, and then met in teams of two to reach consensus on ratings (similar to the Project 2061 method). This consensus method was designed to create one consensus rating per NAEP standard with the help of a moderator and was not intended to allow for disagreements. This methodology was determined to be best suited to the scope and timing of this study. The consensus methodology is designed to highlight areas for states to examine, not to gather large amounts of data, record multiple ratings, or measure interrater reliability (see appendix B for more on methodology).

TABLE 1

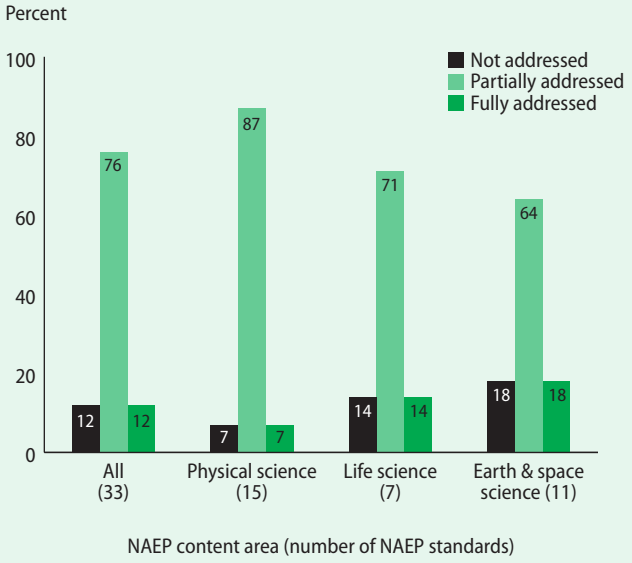
Average ratings of alignment of the Arkansas grade 5 Science Curriculum Framework and the National Assessment of Educational Progress grade 4 science content statements

NAEP content area (number of NAEP standards)	Average rating
Overall physical science (15)	2.0
Matter (6)	2.3
Energy (5)	2.0
Motion (4)	1.8
Overall life science (7)	2.0
Structures and functions of living systems (4)	2.3
Changes in living systems (3)	1.7
Overall Earth and space science (11)	2.0
Earth and space in time (3)	2.0
Earth structures (3)	1.7
Earth systems (5)	2.2
All content (33)	2.0

Note: Rating is based on a scale of 1 to 3, where 1 indicates that state standards do not address NAEP content statement, 2 that they partially address NAEP content statement, and 3 that they fully address or exceed NAEP content statement by targeted grade level.

FIGURE 1

The majority of Arkansas grade 5 standards partially address the National Assessment of Educational Progress content statements



assessment frameworks, Arkansas's alignment was performed with the complete set of its curriculum content.

For grade 4 the NAEP provides 33 distinct content statements (displayed in parentheses in table 1). Four (12 percent) of these content statements are fully addressed by Arkansas standards, 25 (76 percent) partially addressed, and 4 (12 percent) unaddressed (figure 1).

The average alignment rating for grade 4 is 2.0 (table 1). The majority of content statements were given ratings of 2, which means that state standards partially address the NAEP content statements (figure 1 and appendix C).

Areas of full alignment

Four NAEP grade 4 content statements are fully addressed by Arkansas student learning expectations. One of 15 physical science NAEP statements has full alignment with Arkansas standards, as do 1 of 7 life science statements and 2 of 11 Earth and space science statements.

The four NAEP grade 4 content statements fully addressed by the Arkansas Science Curriculum Framework at grade 5 are P4.1—properties of objects and measuring mass and volume, L4.3—interdependence of organisms, including beneficial and detrimental interactions, E4.8—day to day and seasonal changes in weather, and E4.11—human dependence on and change of the environment.

Areas of partial alignment

Twenty-five (76 percent) of NAEP grade 4 content statements have partial alignment, in large part because many Arkansas benchmarks imply content explicitly stated by the NAEP and because the NAEP content was often found to be addressed by Arkansas at a higher grade level than fifth.

Raters found that many Arkansas benchmarks imply content that the NAEP addresses in depth. For example, Arkansas PS.7.2.3 states,

"Demonstrate methods of using electricity to produce light, heat, and sound," while its corresponding NAEP statement P4.7 reads, "Heat (thermal energy), electricity, light and sound are forms of energy." The Arkansas standard does not explicitly mention "forms of energy," but it is implied. In Earth and space science Arkansas ESS.8.29, 8.3.10, and 8.4.11 correspond to NAEP E4.9, which contains content regarding scientists using tools for observing, recording, and predicting weather changes over days and over seasons. The Arkansas statements include content regarding various instruments used in collecting weather data, but imply the content regarding observing, recording, and predicting, as well as the content regarding seasons.

NAEP items are also often addressed in higher Arkansas grade levels. For example, in physical science NAEP's P4.13, which covers objects in motion, was found to match to Arkansas learning expectations only in grade 6, while the elementary school benchmark test in Arkansas is given at grade 5. In addition, in life science NAEP L4.7, with content regarding advantageous survival characteristics of different organisms, was matched to one fourth grade standard that mentions environmental adaptations but also to sixth and eighth grade standards that mention natural selection and the increase in likelihood of survival. In Earth and space science NAEP E4.1 contains content regarding objects in the sky and their patterns of movement, including the changing of paths over the seasons. Arkansas has several learning expectations that match this content in the second and third grades, however, the concept of seasons is not mentioned until the seventh grade (ESS.10.7.5).

Areas of nonalignment

Four NAEP statements are unaddressed by Arkansas learning expectations. In physical science NAEP P4.12 covers relative observation and an object's position. In life science L4.6 states "Plants and animals closely resemble their parents." In Earth and space science E4.7 states, "The sun warms the land, air, and water and helps plants grow" and E4.5 states, "Natural materials have different properties, which sustain plant and animal life."

Areas where Arkansas benchmarks go beyond the NAEP content statements

Arkansas has 83 learning expectations in its grade 5 science framework. The NAEP does not address, in its content statements, the 9 Arkansas statements in nature of science, 24 of the 29 in life science, 15 of the 23 in physical science, and 22 of the 22 in Earth and space science. Eighty-four percent of Arkansas grade 5 standards go beyond NAEP content statements.

The NAEP does not address the nature of science statements because it discusses inquiry in a section separate from the content statements, called "science practices," intended to crosscut all NAEP content.

The reviewers found that very few fifth grade Arkansas standards match well with the NAEP's fourth grade content statements, which the abundance of "HG" and "LG" codes in table C1 in appendix C shows, because Arkansas conducts its elementary benchmark test at grade 5, so most of the Arkansas content that matched NAEP content was found in lower or higher grade levels in Arkansas.

Summary of grade 4 alignment

Nearly all NAEP content items are addressed to some degree by the Arkansas science framework, but the Arkansas statements are typically only partially aligned with NAEP statements, which often were not found at the grade 5 Arkansas level. The Arkansas grade 5 learning expectations mostly went beyond the content covered by the NAEP. However, most

Nearly all NAEP content items are addressed to some degree by the Arkansas science framework, but the Arkansas statements are typically only partially aligned with NAEP statements

TABLE 2

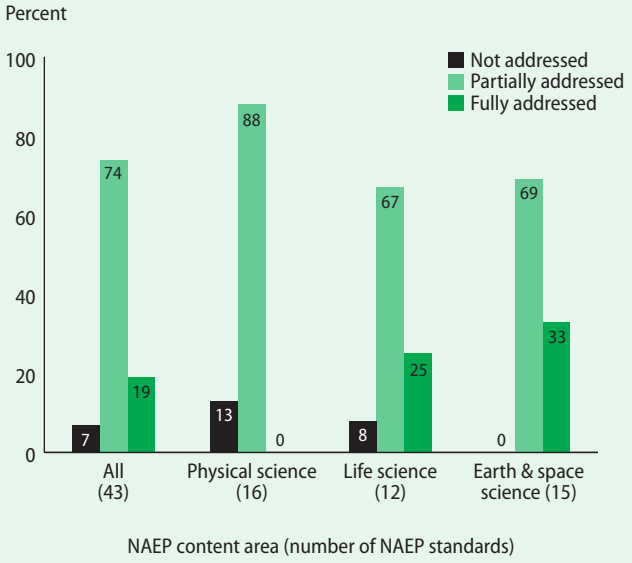
Average ratings of alignment of the grade 7 Arkansas Science Curriculum Framework and the National Assessment of Educational Progress grade 8 science content statements

NAEP content area (number of NAEP standards)	Average rating
Overall physical science (16)	1.9
Matter (7)	2.0
Energy (6)	1.7
Motion (3)	2.0
Overall life science (12)	2.2
Structures and functions of living systems (8)	2.3
Changes in living systems (4)	2.0
Overall Earth and space science (15)	2.3
Earth and space in time (4)	2.5
Earth structures (6)	2.2
Earth systems (5)	2.4
All content (43)	2.1

Note: Rating is based on a scale of 1 to 3, where 1 indicates that state standards do not address NAEP content statement, 2 that they partially address NAEP content statement, and 3 that they fully address or exceed NAEP content statement by targeted grade level.

FIGURE 2

The majority of Arkansas grade 8 standards partially address the National Assessment of Educational Progress content statements



NAEP content was found to be partially aligned with Arkansas content at grade levels above and below fifth grade. The Arkansas content at various grade levels that corresponds to the NAEP content statements are typically partially aligned with NAEP content, as some NAEP content is implied but not explicitly stated in Arkansas standards and, or sufficiently aligned content could be found only at subsequent grade levels. The overall alignment rating is 2.0, which indicates partial alignment.

CONTENT ALIGNMENT AT GRADE 8

NAEP grade 8 science standards were compared with the Arkansas Science Curriculum Framework, primarily at grade 7. Arkansas recommended using its Science Curriculum Framework for this study, as the state's assessment specialists stated that all assessment content was drawn from all standards within the curriculum framework. In addition, Arkansas grade 7 student learning expectations were used because Arkansas conducts its statewide middle school exam in the seventh grade.

For grade 8 the NAEP provides 43 distinct content statements (displayed in parentheses in table 2). Eight (19 percent) are fully addressed by Arkansas standards, 32 (74 percent) partially addressed, and 3 (7 percent) unaddressed.

The alignment level between the Arkansas Science Curriculum Framework and the NAEP standards is 2.1, with the majority of NAEP content statements receiving an alignment rating of 2, which indicates partial alignment (figure 2 and appendix D).

Areas of full alignment

Eight NAEP grade 8 content statements are fully addressed by Arkansas standards. Three of 12 life science statements have full alignment, as do 5 of 15 Earth and space science statements.

The eight NAEP grade 8 content statements fully addressed by the Arkansas Science Curriculum Framework were: L8.2—fertilization, cell division, and differentiation; L8.7—ecosystems' support

of organisms, biotic and abiotic factors; L8.9—reproduction; E8.3—fossils as evidence of change; E8.4—Earth processes; E8.10—Earth's magnetic field; E8.12—seasons and their cause; and E8.13—global weather patterns.

Areas of partial alignment

Thirty-two (74 percent) of NAEP grade 8 content statements have partial alignment. NAEP was often found to include more detail within many of its standards than did Arkansas.

Raters repeatedly found that many Arkansas standards do not have as much detail as NAEP's statements; 80 percent of the 32 partially aligned NAEP statements were given a code for "more detail." For example, NAEP P8.8 and P8.9 were matched to Arkansas PS.7.7.3, which states, "Conduct investigations to identify types of kinetic and potential energy." However, the NAEP statements include examples of kinetic and potential energy, while Arkansas's statements do not. Reviewers noted that Arkansas's corresponding standard was much more general than the NAEP standard, which contains specific examples and that the state's standard is performance-based while the NAEP standard is content-based. In life science several examples of NAEP statements containing more detail than Arkansas standards can be found. For example, NAEP L8.5 describes and defines producers, consumers, and decomposers, while Arkansas's corresponding standard LS.4.5.142 includes the terms "producers, consumers, decomposers," but does not define the terms as the NAEP does. Another example of this mismatch in detail can be found in Earth and space science, where NAEP E8.7 is matched with Arkansas ESS.8.7.1. While the Arkansas standard states, "Describe the composition and physical characteristics of the atmosphere," the NAEP more specifically mentions the gases of which the atmosphere is composed and the differences at atmospheric levels.

Areas of nonalignment

Three NAEP statements are unaddressed by the Arkansas Science Curriculum Framework's content statements—two in physical science and one in life science.

In NAEP physical science the unaddressed content statements are P8.11—light energy from the sun and P8.13—nuclear reactions in the sun, light energy from the sun and photosynthesis. In life science the unaddressed statement is L8.10—characteristics of organisms influenced by heredity and the environment.

Areas where Arkansas benchmarks go beyond the NAEP content statements

Arkansas has 85 total student learning expectations listed in the Science Curriculum Framework for grade 7. NAEP does not address more than half of these standards, including the nine Nature of science standards, 17 of the 23 life science standards, 10 of the 21 physical science standards, and 19 of the 32 earth and space science standards.

The NAEP does not address Arkansas nature of science standards because it discusses content related to science inquiry in a section separate from the content statements, called "science practices," intended to crosscut all NAEP content.

The 55 Arkansas grade 7 standards unaddressed by the NAEP are listed at the end of the content alignment table (table D1) for NAEP grade 8 in appendix D.

Summary of grade 8 alignment

The majority of grade 8 content statements are partially aligned between the Arkansas Science Curriculum Framework and the NAEP. Most statements were given alignment ratings of 2 because NAEP content statements typically contain more detail than the corresponding Arkansas standards. More than half of Arkansas grade 7 standards in the Science Curriculum

The majority of grade 8 content statements are partially aligned between the Arkansas Science Curriculum Framework and the NAEP

Framework are unaddressed by the NAEP, most likely because this alignment was performed between the NAEP's more specific content areas, designed specifically for use on an assessment, and Arkansas's more wide-ranging areas of content contained within its entire curriculum framework. The overall alignment rating when comparing the Arkansas Science Curriculum Framework to the NAEP grade 8 content statements was 2.1, indicating partial alignment.

CONTENT ALIGNMENT AT GRADE 12

The primary purpose of this study is to compare the NAEP assessment content standards with the appropriately corresponding state assessment content standards. For Arkansas the most suitable document for comparison for grade 12 is the Arkansas biology curriculum framework because the only subject area in which Arkansas tests its high school students on a statewide basis is biology. Additionally, science specialists in Arkansas indicated that all content items within the curriculum framework are used in developing the statewide tests and that the Biology Curriculum Framework was the most suitable document for use in this study. Therefore, NAEP grade 12 science standards were compared only with the Arkansas biology Science Curriculum Framework.

For grade 12 the NAEP provides 49 distinct content statements (displayed in parentheses in table 3). One (2 percent) is fully addressed by Arkansas learning expectations within the biology curriculum framework, 12 (24 percent) are partially addressed, and 36 (73 percent) are unaddressed.

The average alignment rating for grade 12 is 1.3. The majority of content statements were given ratings of 1, which means that state standards do not address the NAEP content statement (figure 3 and appendix E).

This review used only the Arkansas biology curriculum framework, which does not address

TABLE 3

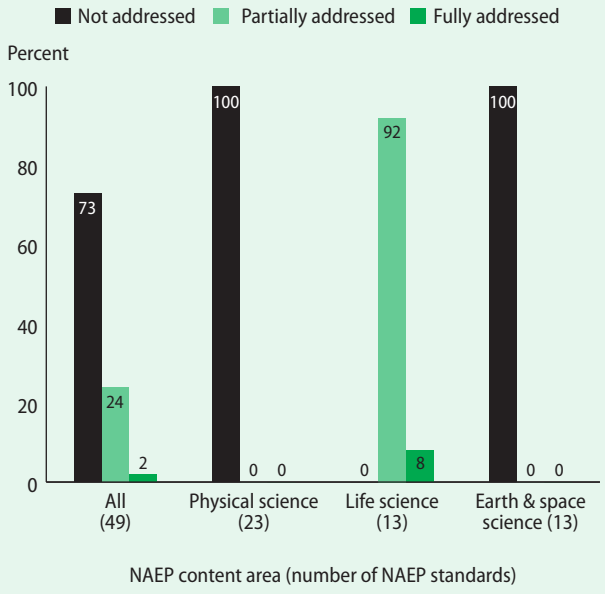
Average ratings of alignment of the Arkansas biology Science Curriculum Framework and the National Assessment of Educational Progress grade 12 science content statements

NAEP content area (number of NAEP standards)	Average rating
Overall physical science (23)	1.0
Matter (7)	1.0
Energy (9)	1.0
Motion (7)	1.0
Overall life science (13)	2.1
Structures and functions of living systems (7)	2.1
Changes in living systems (6)	2.0
Overall Earth and space science (13)	1.0
Earth and space in time (7)	1.0
Earth structures (1)	1.0
Earth systems (5)	1.0
All content (49)	1.3

Note: Rating is based on a scale of 1 to 3, where 1 indicates that state standards do not address NAEP content statement, 2 that they partially address NAEP content statement, and 3 that they fully address or exceed NAEP content statement by targeted grade level.

FIGURE 3

The majority of Arkansas biology standards partially address the National Assessment of Educational Progress life science content statements, but physical science and Earth and space science are not covered



content in the NAEP areas of physical science and Earth and space science. Consequently, reviewers gave ratings of 1 to indicate no alignment within those two areas. For the life science portion of the NAEP, Arkansas biology content had an overall rating of 2.1, which indicates that the biology curriculum framework's content partially covers the life science content of the NAEP.

Areas of full alignment

One NAEP grade 12 content statement is fully addressed by Arkansas high school biology curriculum standards. NAEP L12.1, which addresses the composition of complex molecules that make up living systems, is fully addressed by Arkansas MC.1.B.1, which asks students to describe the structure and function of the major organic molecules found in living systems.

Areas of partial alignment

Twenty-four percent of NAEP grade 12 content statements have partial alignment with the Arkansas biology curriculum framework. Arkansas implies much of the content that NAEP explicitly states.

Arkansas's content statements often address the NAEP content implicitly, as 12 of the 13 life science content statements were given the implied content code. An example of implied content in life science is Arkansas learning expectation MC.1.B.2, which corresponds to NAEP L12.2. The NAEP's content includes details regarding the carrying out of cellular processes by different molecules, including proteins, as well as details regarding the composition and functioning of proteins. Arkansas MC.1.B.2 states only, "Describe the relationship between an enzyme and its substrate molecule(s)." Another example is the alignment between NAEP L12.4 and Arkansas MC.3.B.4. NAEP's content includes plants' conversion of light into high energy sugar molecules, which can be used to make amino acids and other organic molecules, while Arkansas's content includes the conversion of light energy to chemical energy by photosynthetic organisms but does not specify the formation of sugar molecules that contain carbon, hydrogen and oxygen, as the NAEP does.

Areas of nonalignment

All of physical science and Earth and space science standards were unaligned because this comparison was being performed only with the Arkansas biology curriculum framework. Within life science all the NAEP grade 12 content statements were at least partially addressed.

Areas where Arkansas benchmarks go beyond the NAEP content statements

Arkansas has an extensive list of 97 learning expectations in the biology Science Curriculum Framework. The NAEP does not address 76 (78 percent) of them: 15 of the 20 molecules and cells statements, 8 of the 19 heredity and evolution statements, all 22 of the classification and diversity of life statements, 6 of the 11 ecology and behavioral relationships statements, and all 25 of the nature of science statements.

The NAEP does not address the nature of science statements because it discusses inquiry, technology, and various other concepts under nature of science in a section separate from the content statements, called "science practices," intended to crosscut all NAEP content.

The Arkansas biology learning expectations are moderately aligned with NAEP's life science

Because this alignment was being performed between the NAEP physical, life, and Earth and space science standards and only Arkansas biology standards, the NAEP did not address the vast majority of the items within the Arkansas biology curriculum framework. As a curriculum framework, the Arkansas document is intended to contain comprehensive coverage of biology. The NAEP, by contrast, is a test that covers physical science, life science, and Earth and space science and therefore does not extensively cover biology.

Summary of NAEP grade 12 alignment

The Arkansas biology learning expectations are moderately aligned with NAEP's life science, as all NAEP statements are at least partially addressed by Arkansas standards. The Arkansas statements mostly implied the content explicitly stated by the NAEP. The overall alignment rating for NAEP life science was 2.1.

This study is intended to compare the NAEP assessment framework with state assessment frameworks. The most suitable assessment content for this study is in the Arkansas biology curriculum framework because the only subject area in which Arkansas tests its high school students on a statewide basis is biology and the state does not have a separate and readily accessible assessment content document. Because this alignment was performed using only the Arkansas biology curriculum framework, Arkansas is mostly unaligned with the NAEP, which includes content in physical and Earth and space sciences, and Arkansas's biology content was found to greatly exceed what is covered by the NAEP.

One reviewer found the framework easy to understand and the coding and organization easy to follow. However, another reviewer commented that topics appeared too much as lists instead of specifying what concepts students should understand and how they should be able to apply the concepts.

Because only Arkansas's biology content was reviewed for this study, the overall alignment between all NAEP content and Arkansas biology was 1.3, indicating an overall level of nonalignment. However, upon examining only the life science section of the NAEP, the alignment was 2.1, indicating partial alignment.

APPENDIX A
THE DOCUMENTS COMPARED

This alignment study used the Science Framework for the 2009 National Assessment of Educational Progress and the accompanying Science Assessment and Item Specifications as its baseline for comparison (National Assessment Governing Board, 2006). The two NAEP documents were developed by a steering and a planning committee made up of leaders in science, science education, general education, assessment, and various public constituencies. The documents went through public and committee review processes before finally being adopted and published in 2006 by the National Assessment Governing Board. The 2009 Framework will guide the test development until approximately 2017.

NAEP assessments in science are administered across all states in the nation according to a statistical sampling plan and to selected urban areas. The NAEP tests students at grades 4, 8, and 12 every four to five years and is intended to provide a snapshot of what students at those grades know and can do in science. In addition, the resulting data on student knowledge and performance have been accompanied by background information that allows analyses of a number of student demographic and instructional factors related to achievement. The assessments have been designed to allow comparisons of student performance over time and among subgroups of students according to region, parental education, gender, and race/ethnicity.

The NAEP 2009 Science Assessment will include two separately timed, 25-minute sections of science items and extra 30-minute sections for hands-on performance tasks and interactive computer tasks, which will be given only to a subset of all students sampled. There will be multiple test booklet forms, and a matrix sampling design will be used so that students do not all receive the same items. Instead of detailing the number of test items that will fall in various categories, the NAEP outlines its distribution of items by "student response time" and stipulates that 50 percent of student response time will be used in answering multiple-choice items and the other 50 percent in constructed-response items. Constructed-response items will include short constructed-response, extended constructed-response, and concept-mapping tasks. In addition, at least one of each of the following item types must be used at each grade level: item clusters, predict-observe-explain item sets, hands-on performance tasks, and interactive computer tasks. Table A1 shows the stipulated distribution of items for the NAEP 2009 as a percent of student response time:

The NAEP science content used in this study is shown in detail in chapter two, "Science Content," which is extracted from the Science Assessment and Item Specifications for the 2009 NAEP (National Assessment Governing Board, 2006).

This comparison was intended to be performed between NAEP and a state assessment framework. However, science specialists in Arkansas claimed that their statewide exams draw from the entire set of standards within the Science Curriculum

TABLE A1
National Assessment of Educational Progress distribution of items and standards by content area and grade

	Grade 4		Grade 8		Grade 12	
Content area	Share of response time (percent)	Number of content standards	Share of response time (percent)	Number of content standards	Share of response time (percent)	Number of content standards
Physical science	33.3	15	30.0	16	37.5	23
Life science	33.3	7	30.0	12	37.5	13
Earth and space science	33.3	11	40.0	15	25.0	13

Frameworks, so this alignment was performed using Arkansas's Science Curriculum Framework that specifies what science topics should be taught.

The Arkansas documents used in this review were the Arkansas Science Curriculum Framework: Grades K–8 (Arkansas Department of Education, 2005b) and the Arkansas Science Curriculum Framework: Biology (Arkansas Department of Education, 2005a). The NAEP is administered to students in grades 4, 8, and 12, while Arkansas gives its statewide tests in grade 5, grade 7, and biology. Therefore, in comparing Arkansas's Science Curriculum Framework to the NAEP standards, the Arkansas standards at grades 5, 7, and Biology were used, in an effort to compare the Arkansas standards that were most likely to appear on the assessments to the NAEP assessment standards.

The Arkansas state testing program for science is still in the developmental stages. A recent Arkansas Department of Education memo (Arkansas Department of Education, 2006) indicated that benchmark science exams will be operational in April 2007 and that the new end-of-course biology field test would be field tested in the spring of 2007 and operational for 2008. The memo also indicated that the end-of-course biology field test would include both multiple-choice and open-response items.

There were differences between the grades at which NAEP assessments are given and the grades at which the Arkansas benchmark exams are administered. At the elementary school level NAEP tests are administered at grade 4, but in Arkansas the assessment is given at grade 5, so the fourth grade NAEP standards were compared primarily with the fifth grade Arkansas standards, which would most be the content on which the fifth grade benchmark exams would be based. At the middle school level the NAEP is given at grade 8, while the Arkansas benchmark exam is given at grade 7. Thus, NAEP grade 8 content was compared with Arkansas curriculum standards at grade 7. However, in general, if there were Arkansas learning expectations at other grades that addressed NAEP content statements at earlier or later grades, they were noted in the alignment tables shown in appendixes C–E. At the high school level the NAEP is given at grade 12 to test all science knowledge and skills that have been acquired in high school up to and including that grade. It addresses all three content areas tested by the NAEP, which include life science, physical science, and Earth and space science. The Arkansas high school benchmark exam, however, is scheduled to be given only to those enrolled in biology. Thus it is to be expected that the Arkansas end-of-course biology exam will not cover all the content found in the NAEP grade 12.

The distribution of learning expectations by each strand in grade 5, grade 7, and biology are given in tables A2 and A3.

TABLE A2
Distribution of science learning expectations by strand, grades 5 and 7

Content area	Grade 5 Number of learning Expectations	Grade 7 Number of learning expectations
Nature of science	9	9
Life science	29	23
Physical science	23	21
Earth and space science	22	32
Total	83	85

TABLE A3
Distribution of science learning expectations by strand, high school biology

Content area	Biology Number of learning expectations
Molecules and cells	20
Heredity and evolution	19
Classification and the diversity of life	22
Ecology and behavioral relationships	11
Nature of science	25
Total	97

APPENDIX B
HOW THE STUDY WAS CONDUCTED

The chief research question driving this study was "To what extent do current state assessment standards cover the content on which NAEP 2009 assessments will be based?" This question was addressed using curriculum standards instead of assessment standards because the Arkansas state science specialists indicated that all curriculum standards were used for test development and no subset of "assessment standards" was available. The studies for the other Southwest Region states address the question "To what extent do current state assessment specifications align with the NAEP 2009 assessment specifications?" but there were no science assessment specifications readily available for use in the study for Arkansas.

The methodology used to answer the chief research question followed the successful pattern of a similar study conducted by WestEd in New England, which examined the alignment of math and reading standards with the NAEP. The methodology developed by WestEd for the New England study was designed to include all the most prominent alignment methodologies, discussed below. Thus far, alignment studies and methods have focused on aligning standards and tests, whereas the objective of this study was to compare one set of assessment standards and specifications with another. In this study, however, the methodology is based upon methodologies for aligning standards to tests, because similar principles are used in both types of alignments.

Eight independent alignment methodologies are examined in *Imperfect Matches: The Alignment of Standards and Tests* (Rothman, 2003), which describes methodologies by Norman L. Webb, Karen K. Wixson, Andrew C. Porter, Achieve, the Buros Center for Testing, the American Association for the Advancement of Science's Project 2061, CRESST, and SRI International.

- Webb's method (Webb, 1997, 1999) involves evaluating the degree to which consistent content categories or content strands are found between the standards and assessments (categorical concurrence), the degree to which the standards and assessments cover content to the same depth and have similar cognitive demands (depth-of-knowledge consistency), the degree to which assessments cover the same range of content as the corresponding standards (range-of-knowledge correspondence), and the degree to which the distribution of assessment items match the distribution of content standards (balance of representation).

- Wixson's method (Wixson et al., 2002) is a modified version of Webb's and includes range-of-knowledge correspondence, balance of representation, whether or not each objective was covered by at least one assessment item (coverage), depth-of-knowledge consistency, and the extent to which the philosophy underlying the assessment matched the philosophy of the standards (structure of knowledge comparability).

- Porter's method (Porter, 2002) involves a matrix with rows representing topics and columns representing categories of cognitive demand, in which reviewers record values to represent the level of alignment.

- Achieve's method (Achieve, 2003) involves examining test blueprints to see whether they adequately reflected the map of test items to standards. It also involves examining the quality of the match between an assessment item and its corresponding standard (content centrality), the degree to which an item appropriately assesses the "performance" or cognitive demand presented by a standard (performance centrality), the degree to which the assessment's difficulty matches the difficulty presented by the standard (challenge), the degree to which the assessment's emphasis on content matches the standard's emphasis on content (balance) and the degree to which the assessment's breadth of content matches the standard's breadth of content (range).

- The Buros Center's methodology uses teachers to record four levels of alignment of items to standards (Impara, 2001).

- The Project 2061 methodology, developed by the American Association for the Advancement of Science, includes independently rating materials, and then meeting in two-person teams to reach a consensus that would be reconciled by Project 2061 staff (Stern & Ahlgren, 2002).

- The CRESST methodology includes identifying corresponding content topic(s), rating the centrality of the item to the topic, and rating the depth-of-knowledge level (Herman, Webb, & Zuniga, 2003).

- SRI International created codes for various portions of standards that were used to perform the alignment and to determine the degree of matching (Kreikemeier, Quellmalz, & Haydel, 2004).

The WestEd New England methodology was designed to include the major alignment methodologies. The developed methodology involved a "quality review" of grade level expectations within grades and across grades. Within grades a methodology was employed to account for depth of knowledge, breadth of knowledge, clarity, consistency, reasonableness, and assessability. Across grades, the study examined categorical concurrence, consistency, and assessability.

The study also involved an "alignment review" in which a methodology of examining gaps, order, depth and breadth was employed in order to compare the under-review grade level expectations with external referents. More specifically, the first step in the alignment review was to perform "gap analyses." Reviewers were to identify content in the grade level expectations that was absent in the external referent and content in the external referent absent in the grade level expectations. Reviewers then examined "order" to determine whether grade level expectations were included at the same grade level as matching content in the external referent. Lastly, reviewers examined "depth and breadth" to determine if the content of the grade level expectations reflected the intended depth and breadth of the external referent. Because the alignment study in this report, which compares Arkansas and NAEP, focuses only on examining alignment between Arkansas curriculum standards and NAEP 2009 assessment standards, only part of WestEd's New England study methodology was used.

In this study, reviewers followed the methodology of the portion of the previous study examining alignment between two sets of standards. Reviewers performed gap analyses to identify content included in one set of standards but not the other, identified issues of order so they could reveal differences in the grade levels at which standards appear, and examined depth-of-knowledge and range-of-knowledge correspondence (following Webb's and Wixson's criteria) to determine whether there was a match between Arkansas and NAEP in the level of detail, the cognitive demands, and the range of content covered. A coding scheme (similar to that of the Buros Center) was used to indicate alignment issues and reviewer ratings, and a matrix-like format (similar to Porter's method) was created to facilitate alignment.

Reviewers attended several training sessions and then met in teams of two to reach consensus on ratings (similar to the Project 2061 method). This consensus method was designed to create one consensus rating per NAEP standard with the help of a moderator and was not intended to allow for disagreements. This methodology was determined to be best suited to the scope and timing of this study. The consensus methodology is designed to highlight areas for states to examine, not to gather large amounts of data, record multiple ratings, or measure inter-rater reliability.

The content reviews

State standards detail what students are expected to know and do, and as such they are a crucial

area for examination. Assessment standards or, in this case, curriculum standards, form the basis from which test items are conceived and developed, and they ultimately determine the content that appears on tests. Therefore, this study compared state curriculum standards to NAEP content statements through the completion of content reviews.

The content reviews were conducted by a team of six science educators under the leadership of a senior reviewer. The team was directed by Dr. Timms, who is a senior assessment researcher in the mathematics, science and technology program at WestEd and managing director of the Center for Assessment and Evaluation of Student Learning. The senior reviewer is a retired Biology and AP Biology teacher with 37 years of classroom experience, is a recipient of the Outstanding Biology Teacher Award for the state of California, and has worked in various teacher professional development capacities, including work with the Teacher Assessment Project and the National Board for Professional Teaching Standards.

The six science educators were chosen based on recommendations by the senior reviewer. The team was composed of individuals with science education experience ranging from serving on the National Board for Professional Teaching Standards' Science Committee and co-chairing the California Science Teachers Association Conference to being a technology instructor at a local university to developing widely used science curricula. All six reviewers are current, credentialed middle and high school science teachers. The reviewers have science teaching experience covering the full range of science content areas. Currently, four of the reviewers teach integrated science, one teaches Earth Science, three teach Biology, one teaches Chemistry, and another is a middle school science teacher. The team was also supported by two research assistants.

To ensure that the review was systematic, WestEd developed a crosswalk instrument that was used to evaluate the alignment of the state assessment standards to the content standards contained in the new NAEP 2009 *Science Framework*. These crosswalk instruments contained NAEP standards at the appropriate grade level in the leftmost column, blank cells in the next column for reviewers to fill in corresponding state assessment standards, another column for providing ratings, a column for assigning codes, and a final column for various notes. Completed crosswalk instruments, or "alignment tables." can be found in appendixes C–E. An extract of a completed crosswalk instrument is given, along with explanations, in figure B1.

Codes were used to indicate the Arkansas content. The codes used in this study followed Arkansas's prescribed coding format, which follows the pattern of strand, standard number, grade level, and student learning expectation number. For example, ESS.10.5.1 indicates Earth and space science, standard 10, 5th Grade, student learning expectation 1. In biology, MC.1.B.1 indicates molecules and cells, standard 1, biology, and student learning expectation 1. The codes for the various strands are as follows:

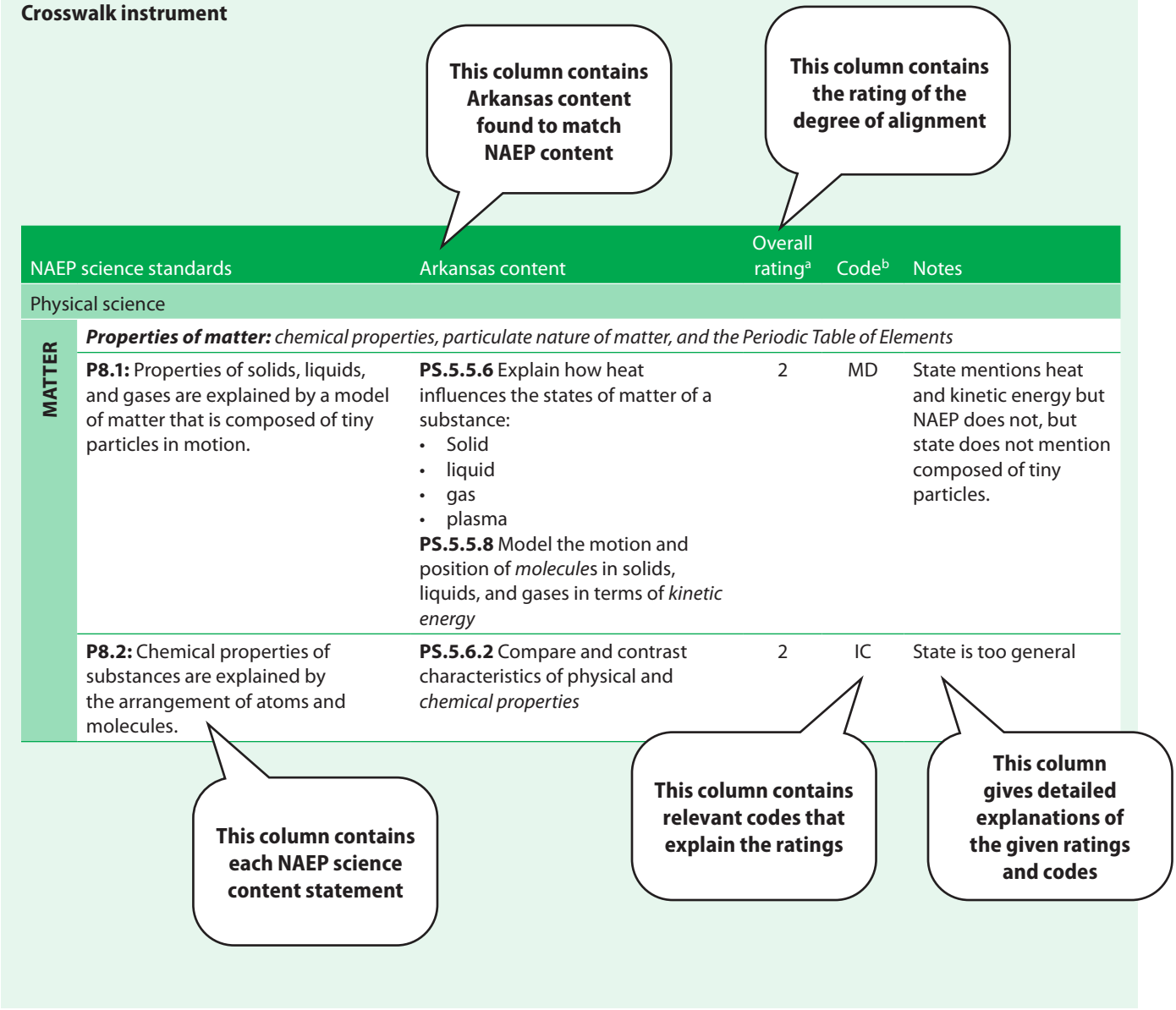
NS = Nature of science
LS = Life science
PS = Physical science
ESS = Earth and space science
MC = Molecules and cells
HE = Heredity and evolution
CD = Classification and diversity
EBR = Ecology and behavioral relationships

The rating scale was:

1—State standards do not address NAEP content statement
2—State standards partially address NAEP content statement
3—State standards fully address or exceed NAEP content statement by targeted grade level

When there was partial or nonalignment (ratings 2 or 1), the reviewers used a letter coding scheme

FIGURE B1
Crosswalk instrument



NAEP science standards	Arkansas content	Overall rating[a]	Code[b]	Notes
Physical science				
MATTER	***Properties of matter:*** *chemical properties, particulate nature of matter, and the Periodic Table of Elements*			
P8.1: Properties of solids, liquids, and gases are explained by a model of matter that is composed of tiny particles in motion.	**PS.5.5.6** Explain how heat influences the states of matter of a substance: • Solid • liquid • gas • plasma **PS.5.5.8** Model the motion and position of *molecules* in solids, liquids, and gases in terms of *kinetic energy*	2	MD	State mentions heat and kinetic energy but NAEP does not, but state does not mention composed of tiny particles.
P8.2: Chemical properties of substances are explained by the arrangement of atoms and molecules.	**PS.5.6.2** Compare and contrast characteristics of physical and *chemical properties*	2	IC	State is too general

to indicate the reason for the lack of alignment. The coding scheme was:

IC—Implied content	The content seems to be implied as part of the standard, but it is not explicitly stated.
LG—Content covered at a lower grade level	The NAEP standard is partially or fully covered at a lower state grade level.
HG—Content covered at a higher grade level	The NAEP standard is partially or fully covered at a higher state grade level.
MC—More content	The NAEP standard contains more content than do corresponding state standards.
MD—More detailed content	The NAEP standard contains content that is more detailed than corresponding state standards.

Reviewers also added explanatory notes to the alignment ratings to indicate precisely the reason for the partial or non-alignment. There were separate instruments for grades 4, 8, and 12, and within each grade level the content was divided into Earth and space science, life science, and physical science categories. Based on a combination of their scientific and grade level experience, the six reviewers worked in teams of two reviewers per grade level. When the NAEP and state grades being compared did not match (e.g. when comparing NAEP 4th grade with Arkansas 5th grade), content statements were considered to be at the

same grade for assignment of alignment ratings (1–3) and codes (HG, LG, and so on).

To ensure the consistent application of the crosswalk instrument by each reviewer, the alignment team attended training sessions spread over several weeks and conducted by Dr. Timms. The training comprised four sessions. Session one included a review of a previous WestEd alignment study to allow teachers to understand the scope of the project and the methodology. The team was also given an introduction to the NAEP standards and then asked to carefully read the NAEP framework standards document before the second session. The second training session included a review and discussion of the NAEP standards and an overview of each of the REL Southwest Region's state assessment standards. Reviewers were then asked to complete an in-depth reading of one of the states' assessment standards. During the third training session, reviewers were introduced to the crosswalk instrument and asked to use it to begin performing an alignment. Reviewers then individually completed an alignment for one state on their own.

During the final training session, the teams at each grade level met to practice consensus-building and establish the criteria for assigning each rating. One criterion was to compare one NAEP standard to as many state standards as possible, and to assign an overall alignment rating based upon the sum of all state standards compared to the single NAEP standard in question. Another criterion was to give a rating of 2 for alignments in which the state standard addressed only one portion (sometimes one sentence) of the NAEP statement. A third criterion was to assign ratings of 2 to alignments for which the NAEP contained more content or more detailed content than the state standards, or for which the state appeared to imply but not explicitly state the content found in the NAEP. If a matching standard was found at a higher state grade level than the NAEP grade level, a rating of 2 was given. If a matching state standard was found at a lower grade level but did not appear to fully address the NAEP standard, a rating of 2 was also given.

As part of the stipulated methodology, the reviewers first conducted independent reviews without consulting with partners. Each began with a review of the set of state standards to get an overall impression of their content and structure. Next, the reviewer used the crosswalk instrument to do a more detailed examination starting with a NAEP content statement and then searching the state standards for those that covered all or part the same content. The reviewer continued in this way, systematically matching the state content standards to the NAEP content statements and recording the results in the crosswalk instrument table. After all the NAEP content statements had been covered, the reviewer applied the three-point rating system to determine the level of alignment for each NAEP content statement.

When both reviewers for a grade level had completed their individual reviews, they met under the guidance of the senior reviewer to compare their ratings and reach a consensus. When they disagreed on which state standard(s) matched a particular NAEP content statement or their ratings were not the same, they re-examined the content in question and discussed their differing viewpoints. The purpose was to reach a consensus so that there was a single alignment table for each grade level that represented their combined review. The senior reviewer moderated the discussion to reinforce the established rating criteria and help reviewers achieve consensus. The alignment tables are shown in detail in appendixes A–C.

When the consensus alignment tables were complete, a WestEd researcher summarized them quantitatively by calculating the average ratings organized by each of the three major NAEP content areas of Physical Science, Life Science, and Earth and Space Science. These average ratings are intended to be summaries of how the state's assessment content matches the NAEP content statements and to allow the reader to quickly identify possible areas for revision. In addition, the researcher wrote a report on the results, which summarized the areas of full alignment, partial alignment, nonalignment, and areas where the state standards went beyond the NAEP content statements.

APPENDIX C
CONTENT ALIGNMENT TABLE FOR GRADE 4

TABLE C1
Alignment of National Assessment of Educational Progress grade 4 science and Arkansas grade 5 standards

NAEP science standards	Arkansas content	Overall rating[a]	Code[b]	Notes
Physical science				
MATTER	***Properties of matter:*** *physical properties common to all objects and substances and physical properties common to solids, liquids and gases*			
P4.1: Objects and substances have properties. Weight (mass) and volume are properties that can be measured using appropriate tools.	**NS.1.4.6** Estimate and measure length, *mass*, *temperature*, capacity/volume, and elapsed time using International System of Units (SI) **PS.5.5.2** Conduct *scientific investigations* on *physical properties* of objects **PS.5.5.3** Identify common examples of *physical properties:* • length • mass • area • perimeter • texture • taste • odor • color • elasticity **PS.5.3.3** Determine the *mass* of solids	3	LG	
P4.2: Objects vary in the extent to which they absorb and reflect light and conduct heat (thermal energy) and electricity.	**PS.5.2.2** Investigate the effect of physical phenomena on various materials (e.g., heat absorption by different colored materials) **PS.7.3.1** Classify materials as those which can *reflect*, *refract*, or absorb light **PS.7.4.2** Classify electrical *conductors* and electrical *insulators* **PS.7.5.1** Summarize how light can interact with *matter* through *absorption*, *refraction*, and *reflection* **PS.7.5.2** Investigate how light travels and interacts with an object or material	2	LG IC	Missing "conduct heat"
P4.3: Matter exists in several different states; the most commonly encountered are solid, liquid, and gas. Each state of matter has unique properties. For instance, gases are easily compressed while solids and liquids are not. The shape of a solid is independent of its container; liquids and gases take the shape of their containers.	**PS.5.4.3** Compare and contrast gases to solids and liquids **PS.5.5.6** Explain how heat influences the states of matter of a substance: • solid • liquid • gas • plasma **PS.5.5.5** Identify characteristics and common examples of physical changes **PS.5.5.7** Demonstrate the effect of changes in the *physical properties* of *matter*	2	IC	Does not state "gas … compress" or shape

	NAEP science standards	Arkansas content	Overall rating[a]	Code[b]	Notes
Physical science					
MATTER	**P4.4:** Some objects are composed of a single substance; others are composed of more than one substance.	**PS.5.5.1** Identify the relationship of *atoms* to all *matter* **PS.5.7.4** Compare and contrast properties of *compounds* to those of the *elements* that compose them: **salt:** sodium, chlorine **water:** hydrogen, oxygen **carbon** dioxide: carbon, oxygen **PS.5.7.6** Classify substances as • elements • compounds • mixtures	2	HG	
	P4.5: Magnets can repel or attract other magnets. They can also attract certain nonmagnetic objects at a distance.	**PS.5.1.1** Compare and contrast objects according to the single properties of • size • color • shape • texture • magnetism **PS.7.3.4** Differentiate between magnets and non-magnets **PS.7.3.5** Describe the effect of distance on attraction and repulsion **PS.7.3.6** Construct a magnet by the "Touch/Stroke" method **PS.7.5.5** Demonstrate techniques for forming and separating *mixtures*: • mixing • magnetic attraction • evaporation • filtration • chromatography • settling	2	LG IC	Doesn't mention non-magnetic
	Changes in matter: *changes of state*				
	P4.6: One way to change matter from one state to another and back again is by heating and cooling.	**PS.5.5.4** State characteristics of physical changes **PS.5.5.5** Identify characteristics and common examples of physical changes **PS.5.5.6** Explain how heat influences the states of matter of a substance: • solid • liquid • gas • plasma	2		Doesn't mention "cooling"
ENERGY	***Forms of energy:*** *examples of forms of energy*				
	P4.7: Heat (thermal energy), electricity, light, and sound are forms of energy.	**PS.7.2.3** Demonstrate methods of using *electricity* to produce light, *heat*, and sound	2	IC	Does not say are forms of energy, but in Energy standard, needs to be retaught at 5th

(CONTINUED)

TABLE C1 (CONTINUED)

Alignment of National Assessment of Educational Progress grade 4 science and Arkansas grade 5 standards

NAEP science standards		Arkansas content	Overall rating[a]	Code[b]	Notes
Physical science					
ENERGY	**P4.8:** Heat (thermal energy) results when substances burn, when certain kinds of materials rub against each other, and when electricity flows though wires. Metals are good conductors of heat (thermal energy) and electricity. Increasing the temperature of any substance requires the addition of energy.	**PS.7.4.1** Interpret trends in *temperature* over time using the Celsius scale **PS.7.2.3** Demonstrate methods of using *electricity* to produce light, *heat*, and sound **PS.7.4.2** Classify electrical *conductors* and electrical *insulators* **PS.6.6.4** Recognize and give examples of different types of *forces*: • gravitational forces • magnetic forces • friction	2	HG	Missing: friction, metals conduct heat and addition of energy required
	P4.9: Light travels in straight lines. When light strikes substances and objects through which it cannot pass, shadows result. When light travels obliquely from one substance to another (air and water), it changes direction.	**PS.7.3.1** Classify materials as those which can *reflect*, *refract*, or absorb light **PS.7.5.1** Summarize how light can interact with *matter* through *absorption*, *refraction*, and *reflection* **PS.7.5.2** Investigate how light travels and interacts with an object or material **PS.7.5.4** Design and conduct investigations of transparent, *translucent*, and *opaque* as applied to light	2	LG IC	Shadows not mentioned
	P4.10: Vibrating objects produce sound. The pitch of sound can be varied by changing the rate of vibration.	**PS.6.3.2** Investigate the relationship between sound and wave motion **PS.6.3.3** Determine the impact of the following *variables* on pitch: • length • mass • tension • state of matter	2	LG IC	Vibration not mentioned, implied

NAEP science standards	Arkansas content	Overall rating[a]	Code[b]	Notes
Physical science				
ENERGY	***Energy transfer and conservation:*** *electrical circuits*			
	P4.11: Electricity flowing through an electrical circuit produces magnetic effects in the wires. In an electrical circuit containing a battery, a bulb, and a bell, energy from the battery is transferred to the bulb and the bell, which in turn transfer the energy to their surroundings as light, sound, and heat (thermal energy).	**PS.7.2.3** Demonstrate methods of using *electricity* to produce light, *heat*, and sound **PS.7.4.3** Construct simple circuits from circuit diagrams **PS.6.8.2** Conduct investigations demonstrating the field *force* (lines of *force*) in magnetic fields **PS.6.8.3** Design and conduct investigations applying *variables* affecting the strength of an *electromagnet* **PS.6.8.4** Analyze and compare the relationship between *electricity* and *magnetism* **PS.7.6.2** Summarize the application of the law of conservation of energy in real world situations: **electrical** *energy* into mechanical *energy* **electrical** *energy* into *heat* **chemical** *energy* into mechanical *energy* • chemical energy into light **PS.7.8.1** Construct *open* and *closed* electrical *circuits:* *series circuits* • parallel circuits **PS.7.8.2** Describe and diagram *open* and *closed* series and *parallel circuits* **PS.7.8.3** Compare and contrast open and closed series circuits and parallel circuits	2	HG	Circuit components not specified, Higher grade
MOTION	***Motion at the macroscopic level:*** *descriptions of position and motion*			
	P4.12: An object's position can be described by locating the object relative to other objects or a background. The description of an object's motion from one observer's view may be different from that reported from a different observer's view.		1	
	P4.13: An object is in motion when its position is changing. The speed of an object is defined by how far it travels divided by the amount of time it took to travel that far.	**PS.6.6.7** Describe the effects of *force:* • move a stationary object • speed up, slow down or change the direction of motion • change the shape of objects **PS.6.6.9** Conduct investigations to calculate the change in *speed* caused by applying *forces* to an object	2	HG	Distance/time not mentioned

(CONTINUED)

TABLE C1 (CONTINUED)

Alignment of National Assessment of Educational Progress grade 4 science and Arkansas grade 5 standards

NAEP science standards	Arkansas content	Overall rating[a]	Code[b]	Notes
Physical science				
MOTION	***Forces affecting motion:*** *the association of changes in motion with forces and the association of objects falling toward Earth with gravitational force*			
P4.14: The motion of objects can be changed by pushing or pulling. The size of the change is related to the size of the force (push or pull) and the weight (mass) of the object on which the force is exerted. When an object does not move in response to a push or a pull, it is because another push or pull (friction) is being applied by the environment.	**PS.6.2.1** Investigate the relationship between *force* and motion **PS.6.4.1** Investigate the relationship between force and direction **PS.6.4.2** Investigate the relationship between *force* and *mass* **PS.6.6.4** Recognize and give examples of different types of *forces*: • gravitational forces • magnetic forces • friction	2	LG IC HG	Push/pull not mentioned Friction only listed as a force Reteach in 5th
P4.15: Earth pulls down on all objects with a force called gravity. With a few exceptions (helium filled balloons), objects fall to the ground no matter where the object is on Earth.	**PS.6.K.3** Demonstrate the effects of the *force of gravity* on objects **PS.6.6.4** Recognize and give examples of different types of *forces*: **gravitational** *forces* **magnetic** *forces* • friction **PS.6.6.5** Understand why objects have *weight*	2	LG HG	Earth not specified as source of force Exceptions not mentioned
Life science				
STRUCTURES AND FUNCTIONS OF LIVING SYSTEMS	***Organization and development:*** *basic needs of organisms*			
L4.1: Organisms need food, water, and air; a way to dispose of waste; and an environment in which they can live.	**LS.2.6.7** Describe the relationship between organ function and the following needs of cells: • oxygen • food • water • waste removal **LS.4.5.5** Examine the role of *limiting factors* on the *carrying capacity* of an *ecosystem:* **food** **space** **water** **shelter**	2	HG	Oxygen missing from 5th, and taught at organ, not organism level, waste taught in 6th

NAEP science standards	Arkansas content	Overall rating[a]	Code[b]	Notes
Life science				
STRUCTURES AND FUNCTIONS OF LIVING SYSTEMS				
Matter and energy transformations: *the basic needs of organisms for growth*				
L4.2: Organisms have basic needs. Animals require air, water, and a source of energy and building material for growth and repair. Plants also require light.	**LS.2.K.4** Identify basic needs of plants and animals: • food • water • light • air • space **LS.2.2.3** Identify basic needs of most plants: *nutrients* **water** **light** **air** *temperature* **space**	2	LG	Source of energy and building materials is missing, needs to be retaught at 5th.
Interdependence: *the interdependence of organisms*				
L4.3: Organisms interact and are interdependent in various ways including providing food and shelter to one another. Organisms can survive only in environments in which their needs are met. Some interactions are beneficial; others are detrimental to the organism and other organisms.		3	HG	

(CONTINUED)

TABLE C1 (CONTINUED)

Alignment of National Assessment of Educational Progress grade 4 science and Arkansas grade 5 standards

NAEP science standards		Arkansas content	Overall rating[a]	Code[b]	Notes
Life science					
STRUCTURES AND FUNCTIONS OF LIVING SYSTEMS	**L4.4:** When the environment changes, some plants and animals survive and reproduce; others die or move to new locations.	**LS.4.5.16** Evaluate positive and negative human effects on *ecosystems* **LS.4.5.4** Evaluate food webs under conditions of stress: • overgrazing • overpopulation • natural disaster • introduction of non-native species • human impact/urban development **LS.4.8.1** Analyze the effect of changes in environmental conditions on the survival of individual *organisms* and entire *species* **LS.4.6.1** Identify *environmental* conditions that can affect the survival of individual *organisms* and entire *species* **LS.3.6.5** Describe behavioral *adaptations* of *organisms* to the *environment:* • hibernation • estivation • tropism • territorial behavior • migration **LS.4.4.1** Recognize *environmental adaptations* of plants and animals	2	HG	This implies natural selection, but migration is not covered until HG
CHANGES IN LIVING SYSTEMS	***Heredity and reproduction:*** *life cycles*				
	L4.5: Plants and animals have life cycles. Both plants and animals begin life and develop into adults, reproduce, and eventually die. The details of this life cycle are different for different organisms.	**LS.3.K.1** Describe plant development and growth **LS.3.K.2** Illustrate *complete metamorphosis* (e.g., butterfly, frog) **LS.3.1.1** Illustrate in*complete metamorphosis* (e.g., grasshopper) **LS.3.1.2** Compare and contrast *complete metamorphosis* and *incomplete metamorphosis* **LS.3.2.1** Illustrate embryonic development (e.g., chicken) **LS.3.2.2** Compare and contrast embryonic development and *incomplete metamorphosis* **LS.3.3.3** Differentiate among *complete metamorphosis*, *incomplete metamorphosis*, and *embryonic development*	2	LG	Life cycles done K,1,2,3, relating to compl and incompl. metamorphorsis, focusing on animals except in K is plants, needs to be retaught in 5th

	NAEP science standards	Arkansas content	Overall rating[a]	Code[b]	Notes
Life science					
CHANGES IN LIVING SYSTEMS	**L4.6:** Plants and animals closely resemble their parents.	**LS.2.4.1** Classify *vertebrates* into major subgroups: • mammals • birds • fish • amphibians • reptiles **LS.2.4.2** Classify some *invertebrates* according to their structure: • mollusks • segmented worms • arthropods **LS.3.8.4** Differentiate among observed inherited traits and acquired traits of plants and animals	2	LG IC	Classification in 4th somewhat implies parental resemblance, 8th gr genetics—inherited traits
	Evolution and diversity: *differences and adaptations of organisms*				
	L4.7: Different kinds of organisms have characteristics that enable them to survive in different environments. Individuals of the same kind differ in their characteristics, and sometimes the differences give individuals an advantage in surviving and reproducing.	**LS.4.4.1** Recognize *environmental adaptations* of plants and animals **LS.4.6.4** Analyze *natural selection* **LS.3.8.16** Identify *genetic* traits that make *organisms* more likely to survive and reproduce in a particular environment	2	HG	
Earth and space science					
EARTH IN SPACE AND TIME	***Objects in the universe:*** *patterns in the sky*				
	E4.1: Objects in the sky have patterns of movement. The sun, for example, appears to move across the sky in the same way every day, but its path changes slowly over the seasons. The moon appears to move across the sky on a daily basis much like the sun.	**ESS.10.2.2** Model the movement of Earth and its moon **ESS.10.2.3** Contrast the visibility of the sun and moon **ESS.10.3.2** Demonstrate the *orbit* of Earth and its moon around the sun **ESS.10.7.5** Identify and model the causes of seasons	2	LG HG	Seasons not mentioned until 7th
	E4.2: The observable shape of the moon changes from day to day in a cycle that lasts about a month.	**ESS.10.2.1** Illustrate four *moon phases:* • full • half • crescent • new **ESS.10.2.2** Model the movement of Earth and its moon **ESS.10.2.3** Contrast the visibility of the sun and moon **ESS.10.6.7** Model moon phases demonstrating the position of Earth, moon, and sun	2	HG	

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TABLE C1 (CONTINUED)

Alignment of National Assessment of Educational Progress grade 4 science and Arkansas grade 5 standards

NAEP science standards	Arkansas content	Overall rating[a]	Code[b]	Notes
Earth and space science				
EARTH IN SPACE AND TIME	***History of Earth:*** *evidence of change*			
E4.3: The surface of Earth changes. Some changes are due to slow processes, such as erosion and weathering, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes.	**ESS.9.4.1** Analyze changes to Earth's surface: • erosion • glaciation • weathering • earthquakes • volcanic activity **ESS.9.8.1** Explain processes that have changed Earth's surface that have resulted from sudden events (e.g., *earthquake*s and volcanoes) and gradual changes (e.g., uplift, *erosion*, and *weathering*)	2	HG	Landslides missing (although implied in erosion) Covered in greater depth between 6, 7, 8
EARTH STRUCTURES	***Properties of Earth materials:*** *natural and human-made materials*			
E4.4: Earth materials that occur in nature include rocks, minerals, soils, water, and the gases of the atmosphere.	**ESS.8.3.1** Distinguish among Earth's materials: • rocks • minerals • fossils • soils **ESS.8.K.3** Classify resources as natural or man-made **ESS.8.7.1** Describe the composition and physical characteristics of the *atmosphere*	2	LG HG	"water, gases" missing
E4.5: Natural materials have different properties, which sustain plant and animal life.	**ESS.8.1.2** Identify common uses of Earth's resources **ESS.8.8.17** Identify the basic *nutrients* needed by plants that are present in soils: • nitrogen • phosphorous • potassium	1		Insufficient specification of resources, taught too low/too high grades N, P, K in soil

	NAEP science standards	Arkansas content	Overall rating[a]	Code[b]	Notes
Earth and space science					
EARTH STRUCTURES	**E4.6:** Some Earth materials have properties that make them useful either in their present form or designed and modified to solve human problems and enhance the quality of life, as in the case of materials used for building or fuels used for heating and transportation.	**ESS.8.4.2** Analyze the impact of using *natural resources* **ESS.8.4.3** Differentiate between renewable and non-renewable resources **ESS.8.4.5** Evaluate the impact of Arkansas' *natural resources* on the economy, including but not limited to • farming • timber • tourism • hunting • fishing **ESS.8.4.6** Evaluate human use of Arkansas' *natural resources* on the *environment*, including but not limited to • mining • clear cutting • dredging **ESS.8.2.4** Identify products derived from *natural resources*	2	LG IC	Fuels not specified
EARTH SYSTEMS	***Energy in Earth systems:*** *role of the sun*				
	E4.7: The sun warms the land, air, and water and helps plants grow.	**ESS.8.7.3** Conduct investigations demonstrating the effects of *solar energy* on the *atmosphere*	1	HG	Helps plants grow missing, as is solar effect on land/water,
	Climate and weather: *local weather*				
	E4.8: Weather changes from day to day and over the seasons.	**ESS.8.K.5** Chart weather conditions every day **ESS.8.K.6** Describe the four seasons **ESS.8.1.3** Chart weather conditions every day **ESS.8.1.4** Identify the sequence of seasons **ESS.8.2.5** Chart weather conditions every day **ESS.8.2.7** Describe characteristics of *cumulus*, *stratus*, and *cirrus* clouds **ESS.8.2.8** Predict weather based on cloud type **ESS.8.3.8** Chart *precipitation* levels over time **ESS.8.4.7** Describe the processes of the *water cycle:* • precipitation • evaporation • condensation **ESS.8.4.8** Organize weather data into tables or charts to identify trends and patterns	3	LG	K-4 studies weather & charts it

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TABLE C1 (CONTINUED)

Alignment of National Assessment of Educational Progress grade 4 science and Arkansas grade 5 standards

NAEP science standards		Arkansas content	Overall rating[a]	Code[b]	Notes
Earth and space science					
EARTH SYSTEMS	**E4.9:** Scientists use tools for observing, recording, and predicting weather changes from day to day and over the seasons.	**ESS.8.2.9** Read a Celsius *thermometer* **ESS.8.3.10** Construct and read a rain gauge **ESS.8.4.11** Construct and read instruments to collect weather data: • *barometer* • weather vane • anemometer	2	IC	Seasons implied
	Biogeochemical cycles: *uses of Earth resources*				
	E4.10: The supply of many Earth resources such as fuels, metals, fresh water, and farmland is limited. Humans have devised methods for extending the use of Earth resources through recycling, reuse, and renewal.	**ESS.8.4.3** Differentiate between renewable and non-renewable resources **ESS.8.4.2** Analyze the impact of using *natural resources* **ESS.8.K.4** Identify ways natural and man-made materials can be reused or recycled **ESS.8.2.4** Identify products derived from *natural resources*	2	LG	Recycle/reuse should be revisited at older level. Limited resources not specified
	E4.11: Humans depend on their natural and constructed environment. Humans change environments in ways that can either be beneficial or detrimental for themselves and other organisms.	**ESS.8.4.2** Analyze the impact of using *natural resources* **ESS.8.4.3** Differentiate between renewable and non-renewable resources **ESS.8.4.4** Evaluate the impact of water pollution **ESS.8.4.5** Evaluate the impact of Arkansas' *natural resources* on the economy, including but not limited to • farming • timber • tourism • hunting • fishing **ESS.8.4.2** Analyze the impact of using *natural resources* **ESS.8.4.4** Evaluate the impact of water pollution **ESS.8.4.8** Organize weather data into tables or charts to identify trends and patterns **LS.4.5.16** Evaluate positive and negative human effects on *ecosystems*	3	LG	

a. Rating is based on a scale of 1 to 3, where 1 indicates that state standards do not address NAEP content statement, 2 that state standards partially address NAEP content statement, and 3 that state standards fully address or exceed NAEP content statement by targeted grade level.

b. Codes are IC (implied content), LG (content covered at a lower grade level), HG (content covered at a higher grade level), MC (more content), and MD (more detailed content). See appendix C for further information.

TABLE C2

Arkansas grade 5 standards not covered by NAEP grade 4 content

Content area	Arkansas grade 5 standards
Nature of science	NS.1.5.1 through NS.1.5.9
Life science	Cells: LS.2.5.1 through LS.2.5.11 Popul & Ecosys: LS.4.5.1 through LS.4.5.3 LS.4.5.6 through LS.4.5.13 LS.4.5.15 & LS.4.5.18
Physical science	Prop of Matter: PS.5.5.1 5.5.2 5.5.8 5.5.9 5.5.10 Motion: PS.6.5.1 through PS.6.5.7 (machines) Energy: PS.7.5.3 7.5.5 7.5.6
Earth and space science	Struc/Prop ESS.8.5.1 through ESS.8.5.10 Cycles: ESS.8.5.11 8.5.12 8.5.13 Earth Hist: ESS.9.5.1 through ESS.9.5.3 Solar Sys: ESS.10.5.1 through ESS.10.5.6

APPENDIX D
CONTENT ALIGNMENT FOR GRADE 8

TABLE D1

Alignment of National Assessment of Educational Progress grade 8 science and Arkansas grade 7 standards

NAEP science standards	Arkansas content	Overall rating[a]	Code[b]	Notes
Physical science				
MATTER	***Properties of matter:*** *chemical properties, particulate nature of matter, and the Periodic Table of Elements*			
P8.1: Properties of solids, liquids, and gases are explained by a model of matter that is composed of tiny particles in motion.	**PS.5.5.6** Explain how heat influences the states of matter of a substance: • Solid • liquid • gas • plasma **PS.5.5.8** Model the motion and position of *molecules* in solids, liquids, and gases in terms of *kinetic energy*	2	MD	State mentions heat and kinetic energy but NAEP does not, but state does not mention composed of tiny particles.
P8.2: Chemical properties of substances are explained by the arrangement of atoms and molecules.	**PS.5.6.2** Compare and contrast characteristics of physical and *chemical properties*	2	IC	State is too general
P8.3: All substances are composed of one or more of approximately one hundred elements. The Periodic Table organizes the elements into families of elements with similar properties.	**PS.5.7.1** Explain how a small number of naturally-occurring *elements* can result in the large variety of substances found in the world	2	MD	No mention of the periodic table
P8.4: Elements are a class of substances composed of a single kind of atom. Compounds are composed of two or more different elements. Each element and compound has physical and chemical properties, such as boiling point, density, color, and conductivity, which are independent of the amount of the sample.	***PS.5.7.6** Classify substances as • elements • compounds • mixtures ****PS.5.7.3** Identify *compounds* as substances consisting of two or more *elements* chemically combined	2	MD	Does not provide examples of physical and chemical properties
P8.5: Substances are classified according to their physical and chemical properties. Metals and acids are examples of such classes. Metals are a class of elements that exhibit common physical properties such as conductivity and common chemical properties such as reacting with nonmetals to produce salts. Acids are a class of compounds that exhibit common chemical properties including a sour taste, characteristic color changes with litmus and other acid/base indicators, and the tendency to react with bases to produce a salt and water.	**PS.5.6.2** Compare and contrast characteristics of physical and *chemical properties* **PS.5.6.3** Conduct investigations using acid/base indicators	2	MD MC	Sate is general, NAEP gives specifics There is a standard which addresses classification but it is classification of –elements,-compounds, -mixtures….? Is this the same but from a different angle? PS.5.6.2 PS.5.6.3

NAEP science standards	Arkansas content	Overall rating[a]	Code[b]	Notes
Physical science				
MATTER	***Changes in matter:*** *physical and chemical changes and conservation of mass*			
	P8.6: Changes of state are explained by a model of matter composed of tiny particles that are in motion. When substances undergo changes of state, neither atoms nor molecules themselves are changed in structure. Mass is conserved when substances undergo changes of state.	* **PS.5.5.8** Model the motion and position of *molecule*s in solids, liquids, and gases in terms of *kinetic energy* ** **PS.5.6.9** Demonstrate the *law* of the *conservation of matter*	2		PS 5.5.8 kinetic theory PS.5.**6**.9 conservation of matter ***Could be a 3 but content is covered at 2 different grade levels.
	P8.7: Chemical changes can occur when two substances, elements, or compounds react and produce one or more different substances, whose physical and chemical properties are different from the reacting substances. When substances undergo chemical change, the number and kinds of atoms in the reactants are the same as the number and kinds of atoms in the products. Mass is conserved when substances undergo chemical change. The mass of the reactants is the same as the mass of the products.	*__PS 5.7.4__ Compare and contrast properties of *compounds* to those of the *elements* that compose them: • salt: sodium, chlorine • water: hydrogen, oxygen • carbon dioxide: carbon, oxygen **PS.5.6.7** Identify characteristics of *chemical changes*: • burning • production of a new substance • production of light • color change • *endothermic* and *exothermic* reactions • *reactivity* **PS.5.6.9** Demonstrate the *law* of the *conservation of matter*	2	MD	Only first sentence addressed in 7th grade PS.5.**6**.7 identify characteristics of chemical change and provides examples to investigate PS.5.**6**.9 Conservation of Matter
ENERGY	***Forms of energy*:** *kinetic energy, potential energy, and light energy from the sun*			
	P8.8: Objects and substances in motion have kinetic energy. For example, a moving baseball can break a window; water flowing down a stream moves pebbles and floating objects along with it.	**PS.7.7.3** Conduct investigations to identify types of *potential energy* and *kinetic energy*	2	MD	Too general - NAEP provides SPECIFIC Examples State is performance based while NAEP is content based
	P8.9: Three forms of potential energy are gravitational, elastic, and chemical. Gravitational potential energy changes in a system as the relative positions of objects are changed. Objects can have elastic potential energy due to their compression, or chemical potential energy due to the nature and arrangement of the atoms.	**PS.7.7.3** Conduct investigations to **identify** types of *potential energy* and *kinetic energy*	2	MD MC	Too general- NAEP provides SPECIFIC Examples State is performance based while NAEP is content based

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TABLE D1 (CONTINUED)
Alignment

	NAEP science standards	Arkansas content	Overall rating[a]	Code[b]	Notes
Physical science					
ENERGY	**P8.10:** Energy is transferred from place to place. Light energy from the sun travels through space to Earth (radiation). Thermal energy travels from a flame through the metal of a cooking pan to the water in the pan (conduction). Air warmed by a fireplace moves around a room (convection). Waves—including sound and seismic waves, waves on water, and light waves—have energy and transfer energy when they interact with matter.	***PS.7.6.4** Investigate the transfer of *energy* in real world situations: • *conduction* • *convection* • *radiation* ****PS.7.8.6** Explain how *energy* is transferred through waves: • *seismic* waves • sound waves • water waves • *electromagnet*ic waves	2	MC	Heat transfer .- PS.7.**6**.4 in sixth grade But other parts are missing until 8th grade Waves not addressed until PS.7.**8**.6—eighth grade
	P8.11: A tiny fraction of the light energy from the sun reaches Earth. Light energy from the sun is Earth's primary source of energy, heating Earth surfaces and providing the energy that results in wind, ocean currents, and storms.	**(PS.7.8.10** Analyze the *electromagnet*ic spectrum**) ?**	1	MD MC HG	Too general and material is covered post-assessment (Arkansas middle school assessment in 7th grade)
	Energy transfer and conservation: *energy transfer and conservation of energy*				
	P8.12: When energy is transferred from one system to another, the quantity of energy before transfer equals the quantity of energy after transfer. For example, as an object falls, its potential energy decreases as its speed, and consequently, its kinetic energy increases. While an object is falling, some of the object's kinetic energy is transferred to the medium through which it falls, setting the medium into motion and heating it.	***PS.7.6.2** Summarize the application of the law of conservation of energy in real world situations: **electrical** *energy* into mechanical *energy* **electrical** *energy* into *heat* **chemical** *energy* into mechanical *energy* **chemical** *energy* into light **PS.7.6.3** Conduct investigations demonstrating how *energy* can be converted from one form to another **PS.6.5.4 (**Compare and contrast *potential energy* and *kinetic energy* as applied to motion**)?**	2	MD MC	Law of conservation PS7.6.2 but provides examples State does not address interaction of energy on medium (heating)
	P8.13: Nuclear reactions take place in the sun. In plants, light from the sun is transferred to oxygen and carbon compounds, which, in combination, have chemical potential energy (photosynthesis).		1		

NAEP science standards	Arkansas content	Overall rating[a]	Code[b]	Notes
Physical science				
MOTION	***Motion at the macroscopic level*:** *speed as a quantitative description of motion and graphical representations of speed*			
	P8.14: An object's motion can be described by its speed and the direction in which it is moving. An object's position can be measured and graphed as a function of time. An object's speed can be measured and graphed as a function of time.	**PS 6.6.7** Describe the effects of *force:* **move** a stationary object *speed* up, slow down or change the direction of motion **change** the shape of objects **PS.6.6.8** Conduct investigations to demonstrate change in direction caused by *force* **PS.6.6.9** Conduct investigations to calculate the change in *speed* caused by applying *force*s to an object	2	MC	State standard does not address graphing.
	Forces affecting motion: *qualitative descriptions of magnitude and direction as characteristics of forces, addition of forces, contact forces, forces that act at a distance, and net force on an object and its relationship to the object's motion*			
	P8.15: Some forces between objects act when the objects are in direct contact or when they are not touching. Magnetic, electrical, and gravitational forces can act at a distance.	**PS 6.6.7** Describe the effects of *force:* **move** a stationary object *speed* up, slow down or change the direction of motion **change** the shape of objects **PS.6.6.8** Conduct investigations to demonstrate change in direction caused by *force* **PS.6.6.9** Conduct investigations to calculate the change in *speed* caused by applying *force*s to an object **PS 6.6.4** Recognize and give examples of different types of *forces*: • gravitational *forces* • magnetic *forces* • friction	2	MD MC	PS 6.**6**.4 gravitational and magnetic forces named, electrical is not addressed
	P8.16: Forces have magnitude and direction. Forces can be added. The net force on an object is the sum of all the forces acting on the object. A nonzero net force on an object changes the object's motion; that is, the object's speed and/or direction of motion changes. A net force of zero on an object does not change the object's motion; that is, the object remains at rest or continues to move at a constant speed in a straight line.	**PS.6.7.2** Conduct investigations demonstrating Newton's first law of motion **PS.6.7.3** Demonstrate Newton's second law of motion	2	MC MD	Forces have magnitude not mentioned Additionally addressed at: PS 6.6.7 PS 6.6.8 PS 6.6.9

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TABLE D1 (CONTINUED)
Alignment

NAEP science standards	Arkansas content	Overall rating[a]	Code[b]	Notes
Life science				
STRUCTURES AND FUNCTIONS OF LIVING SYSTEMS	***Organization and development: basic needs of organisms:*** *the levels of organization of living systems*			
L8.1: All organisms are composed of cells, from just one cell to many cells. About two-thirds of the weight of cells is accounted for by water, which gives cells many of their properties. In multicellular organisms, specialized cells perform specialized functions. Organs and organ systems are composed of cells and function to serve the needs of cells for food, air, and waste removal. The way in which cells function is similar in all living organisms.	***LS.2.7.1** Illustrate the hierarchical relationships of *cells*, *tissues*, *organs*, and *organ systems* ****LS.2.7.2** Analyze how two or more *organs* work together to perform a function (e.g., mouth and stomach to digest food) *****LS.2.6.7** Describe the relationship between organ function and the following needs of cells: • oxygen • food • water • waste removal ******LS.2.5.3** Describe the similarities of basic *cell* functions in all *organisms*	2	MD MC	Hierarchy: cell-> organ system Cell water weight not mentioned in state standard
L8.2: Following fertilization, cell division produces a small cluster of cells that then differentiate by appearance and function to form the basic tissues of an embryo.	**LS.3.7.1** Explain that the fertilized *egg cell* carries *genetic* information from each parent and multiplies to form a complete *organism* **LS.3.7.4** Investigate and analyze the development of *embryos*	3		
	Matter and energy transformations: *the role of carbon compounds in growth and metabolism*			
L8.3: Cells carry out the many functions needed to sustain life. They grow and divide, thereby producing more cells. Food is used to provide energy for the work that cells do and is a source of the molecular building blocks from which needed materials are assembled.	***LS.2.6.7** Describe the relationship between organ function and the following needs of cells: • oxygen • food • water • waste removal	2	MD MC	2.5.3 CELL FUNCTION 2.5.9 CELL RESPIRATION
L8.4: Plants are producers—they use the energy from light to make sugar molecules from the atoms of carbon dioxide and water. Plants use these sugars along with minerals from the soil to form fats, proteins, and carbohydrates. These products can be used immediately, incorporated into the plant's cells as the plant grows, or stored for later use.	**LS 2.5.8** Explain and illustrate photosynthesis	2	MD IC	Photosynthesis addressed at the 5th grade level.

NAEP science standards	Arkansas content	Overall rating[a]	Code[b]	Notes
Life science				
STRUCTURES AND FUNCTIONS OF LIVING SYSTEMS				
L8.5: All animals, including humans, are consumers that meet their energy needs by eating other organisms or their products. Consumers break down the structures of the organisms they eat to make the materials they need to grow and function. Decomposers, including bacteria and fungi, use dead organisms or their products to meet their energy needs.	**LS.4.5.14** Categorize *organisms* by the function they serve in *ecosystems* and food webs: • *predator/prey* • *parasitism* • *producer/consumer/decomposer* • *scavenger* • *herbivore/carnivore/ omnivore*	2	MD	State includes more examples of functions of organisms within food chain/food web but only names them does not give examples.
Interdependence: *specific types of interdependence*				
L8.6: Two types of organisms may interact with one another in several ways: They may be in a producer/consumer, predator/ prey, or parasite/host relationship. Or, one organism may scavenge or decompose another. Relationships may be competitive or mutually beneficial. Some species have become so adapted to each other that neither could survive without the other.	**LS.4.5.17** Describe and illustrate various symbiotic relationships: *parasitism* *mutualism* *commensalism* **LS.4.5.14** Categorize *organisms* by the function they serve in *ecosystems* and food webs: • *predator/prey* • *parasitism* • *producer/consumer/decomposer* • *scavenger* • *herbivore/carnivore/ omnivore* **LS.4.6.2** Conduct simulations demonstrating competition for resources within an *ecosystem*	2	IC	LS 4.**5**.17- symbiosis LS 4.**6.**2 LS 4.5.14 organism function Adaptation where organisms depend on other organism for survival not explicitly mentioned
L8.7: The number of organisms and populations an ecosystem can support depends on the biotic resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition.	**LS.4.6.1** Identify *environmental* conditions that can affect the survival of individual *organisms* and entire *species* **LS.4.8.1** Analyze the effect of changes in environmental conditions on the survival of individual *organisms* and entire *species* **LS.4.5.5** Examine the role of *limiting factors* on the *carrying capacity* of an *ecosystem:* • food • space • water • shelter	3		LS .4.**6**.1 identify env cond for survival LS 4.8.1 Analyze env. cond. For survival LS 4.5.5 examine role of limiting factors
L8.8: All organisms cause changes in the environment where they live. Some of these changes are detrimental to the organisms or other organisms, whereas others are beneficial.	**LS.4.5.16** Evaluate positive and negative human effects on *ecosystems* **LS.4.6.1** Identify *environmental* conditions that can affect the survival of individual *organisms* and entire *species*	2	MD MC	Ls 4.5.16 human effects only LS .4.**6**.1 identify env cond for survival

(CONTINUED)

TABLE D1 (CONTINUED)
Alignment

NAEP science standards	Arkansas content	Overall rating[a]	Code[b]	Notes
Life science				
CHANGES IN LIVING SYSTEMS	***Heredity and reproduction:*** *reproduction and the influence of heredity and the environment on an offspring's characteristics*			
L8.9: Reproduction is a characteristic of all living systems**;** because no individual organism lives forever, reproduction is essential to the continuation of every species. Some organisms reproduce asexually. Other organisms reproduce sexually.	****LS.3.7.7** Differentiate between sexual and *asexual reproduction* in *vertebrates* **plants** ***LS.4.7.1** Explain the role of *reproduction* in the continuation of a *species*	3		
L8.10: The characteristics of organisms are influenced by heredity and environment. For some characteristics, inheritance is more important; for other characteristics, interactions with the environment are more important.		1		
	Evolution and diversity: *preferential survival and relatedness of organisms*			
L8.11: Individual organisms with certain traits in particular environments are more likely than others to survive and have offspring. When an environment changes, the advantage or disadvantage of characteristics can change. Extinction of a species occurs when the environment changes and the characteristics of a species are insufficient to allow survival. 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.	**LS.3.8.13** Identify basic ideas related to biological evolution: **diversity** of *species* **variations** within *species* *adaptation***s** *natural selection* *extinction* of a *species* **LS.3.8.14** Explain that the *fossil* record provides *evidence* of life forms' appearance, diversification, and *extinction* **LS.3.8.16** Identify *genetic* traits that make *organisms* more likely to survive and reproduce in a particular environment	2	HG	LS.3.**8**.16 Could be a 3 but addressed post assessment (in 8th grade instead of 7th grade; Arkansas holds middle school assessment in 7th grade)
L8.12: Similarities among organisms are found in anatomical features, which can be used to infer the degree of relatedness among organisms. In classifying organisms, biologists consider details of internal and external structures to be more important than behavior or general appearance.	**LS.2.8.5** Use a *dichotomous key* to classify *organisms* found in pond water **LS.2.8.8** Identify and describe similarities and differences among *organisms* of different, but closely related taxa (e.g., pine trees, big cats, rodents, ungulates)	2	HG	(classification) Could be a 3 but addressed in 8th grade instead of 7th

NAEP science standards	Arkansas content	Overall rating[a]	Code[b]	Notes
Earth and space science				
EARTH IN SPACE AND TIME	***Objects in the universe:*** *a model of the solar system*			
	E8.1: In contrast to an earlier theory that Earth is the center of the universe, it is now known that the sun, an average star, is the central and largest body in the solar system. Earth is the third planet from the sun in a system that includes eight other planets and their moons, as well as smaller objects, such as asteroids and comets.	**ESS.10.5.2** Demonstrate the order of planets and other space objects in our *solar system* **ESS.10.6.9** Investigate careers, scientists, and historical breakthroughs related to the sun and space travel	2	MC MD	State does not address characteristics of the sun
	E8.2: Gravity is the force that keeps most objects in the solar system in regular and predictable motion. Those motions explain such phenomena as the day, the year, phases of the moon, and eclipses.	**ESS.10.7.1** Identify and model the causes of night and day	2	MC	Does not include gravity, year, phases of moon, or eclipses
EARTH STRUCTURES	***History of Earth:*** *estimating the timing and sequence of geologic events*			
	E8.3: Fossils provide important evidence of how life and environmental conditions have changed in a given location.	**ESS.9.7.1** Analyze charts to infer past atmospheric conditions based on the *organisms* found in the *fossil* record	3		
	E8.4: Earth processes seen today, such as erosion and mountain building, made possible the measurement of geologic time through methods such as observing rock sequences and using fossils to correlate the sequences at various locations.	**ESS.8.6.14** Model the effect of major geological events on land and ocean features: • mountain building • ocean trenches • island formation • mid-ocean ridges	3		
	Properties of Earth materials: *soil analysis and layers of the atmosphere*			
	E8.5: Rocks and rock formations bear evidence of the minerals, materials, temperature/pressure conditions, and forces that created them. Some formations show evidence that they were deposited by volcanic eruptions. Others are composed of sand and smaller particles buried and cemented by dissolved minerals to form solid rock again. Still others show evidence that they were once earlier rock types that were exposed to heat and pressure until they changed shape and in some cases melted and recrystallized.	**ESS.8.5.7** Identify characteristics of *sedimentary, igneous*, and *metamorphic* rocks **ESS.8.5.8** Compare and contrast by investigation characteristics of the three basic types of rocks: *sedimentary* *igneous* *metamorphic* **ESS.8.5.9** Classify the three basic types of rocks **ESS.8.5.13** Describe and illustrate the rock cycle	2	IC MD	Rock Cycle ESS 8.**5**.8 & ESS 8.**5**.13 7,8,9 simply stated 13- implied content NAEP has more specific examples

(CONTINUED)

TABLE D1 (CONTINUED)
Alignment

	NAEP science standards	Arkansas content	Overall rating[a]	Code[b]	Notes
Earth and space science					
EARTH STRUCTURES	**E8.6:** Soil consists of weathered rocks and decomposed organic material from dead plants, animals, and bacteria. Soils are often found in layers with each having a different chemical composition and texture.	**ESS.8.5.11** Investigate the formation of soil	2	IC	ESS 8.**5**.11 Arkansas standard is a performance based statement while the NAEP statement is a content-based statement
	E8.7: The atmosphere is a mixture of nitrogen, oxygen, and trace gases that include water vapor. The atmosphere has a different physical and chemical composition at different elevations.	**ESS.8.7.1** Describe the composition and physical characteristics of the *atmosphere*	2	MD	NAEP more specifically mentions gases and differences at atmospheric levels.
	Tectonics: *the basics of tectonic theory and Earth magnetism*				
	E8.8: The Earth is layered with a lithosphere; hot, convecting mantle; and dense, metallic core.	**ESS.8.6.1** Identify and diagram the layers of the Earth: • crust • mantle • inner and outer core	2	MD IC	ESS 8.6.1—Arkansas only says identify and diagram (too general)
	E8.9: Lithospheric plates on the scale of continents and oceans constantly move at rates of centimeters per year in response to movements in the mantle. Major geological events, such as earthquakes, volcanic eruptions, and mountain building, result from these plate motions.	**ESS.8.6.3** Model how *convection* currents in the mantle affect lithosphere movement	2	MD	NAEP more specific
	E8.10: Earth as a whole has a magnetic field that is detectable at the surface with a compass. Earth's magnetic field is similar to the field of a natural or human-made magnet with north and south poles and lines of force. For thousands of years, people have used compasses to aid in navigation on land and sea.	**ESS.9.7.2** Demonstrate that Earth has a magnetic field that is detectible at the surface with a compass **ESS.9.7.3** Compare and contrast Earth's magnetic field to those of natural or human-made magnets with • North and South poles • lines of force	3		
EARTH SYSTEMS	***Energy in Earth systems:*** *the sun's observable effects*				
	E8.11: The sun is the major source of energy for phenomena on Earth's surface. The sun provides energy for plants to *grow and **drives convection within the atmosphere and oceans, producing winds, ocean currents, and the water cycle.	**ESS.8.7.3** Conduct investigations demonstrating the effects of *solar energy* on the *atmosphere* **ESS.8.7.4** Investigate the effect that oceans have on *climate*	2	MC MD	NAEP states specific examples PBS VS CBS

NAEP science standards		Arkansas content	Overall rating[a]	Code[b]	Notes
Earth and space science					
EARTH SYSTEMS	**E8.12:** Seasons result from annual variations in the intensity of sunlight and length of day, due to the tilt of Earth's rotation axis relative to the plane of its yearly orbit around the sun.	**ESS.8.7.12** Analyze the effect of the shape of Earth and the tilt of Earth's *axis* on *climate* **ESS.10.7.5** Identify and model the causes of seasons	3		
	Climate and Weather: *global weather patterns*				
	E8.13: Global patterns of atmospheric movement influence local weather. Oceans have a major effect on climate because water in the oceans holds a large amount of heat.	***ESS.8.7.2** Investigate the influence of global patterns on local weather: **movement** of air masses *Coriolis effect* *jet stream* **global** wind belts ****ESS.8.7.4** Investigate the effect that oceans have on *climate*	3		
	Biogeochemical cycles: *natural and human-induced changes in Earth materials and systems*				
	E8.14: Water, which covers the majority of Earth's surface, circulates through the crust, oceans, and atmosphere in what is known as the "water cycle." Water evaporates from Earth's surface, rises and cools as it moves to higher elevations, condenses as clouds, falls as rain or snow, and collects in lakes, oceans, soil, and underground.	**ESS.8.7.16** Conduct investigations demonstrating the *water cycle*	2	MD MC IC	Does not include mechanics or the specifics of the water cycle. Does not address soil and underground water.
	E8.15: Human activities, such as reducing the amount of forest cover, increasing the amount and variety of chemicals released into the atmosphere, and intensive farming, have changed Earth's land, oceans, and atmosphere. Studies of plant and animal populations have shown that such activities can reduce the number and variety of wild plants and animals and sometimes result in the extinction of species.	**ESS.8.7.13** Identify and explain the effects that human activities have on weather and *atmosphere* **ESS.8.7.20** Research how human activities may contribute to *global warming*	2	MD	Does not include specific examples of effects.

a. Rating is based on a scale of 1 to 3, where 1 indicates that state standards do not address NAEP content statement, 2 that state standards partially address NAEP content statement, and 3 that state standards fully address or exceed NAEP content statement by targeted grade level.

b. Codes are IC (implied content), LG (content covered at a lower grade level), HG (content covered at a higher grade level), MC (more content), and MD (more detailed content). See appendix C for further information.

TABLE D2

Arkansas grade 7 standards not covered by NAEP grade 8 content

Content area	Arkansas grade 8 standards
Nature of science	NS.1.7.1, NS.1.7.2, NS.1.73, NS. 1.7.4, NS. 1.7.5, NS.1.7.6 NS.1.7.7, NS.1.7.8, NS.1.7.9
Life science	LS.2.7.3, LS.2.7.4, LS.2.7.5, LS.2.7.6, LS2.7.7, LS.2.7.8, LS.2.7.9, LS .2.7.10, LS.3.7.2, LS.3.7.3, LS.3.7.5, LS.3.7.6 LS.3.7.8, LS.3.7.9, LS.3.7.10, LS.3.7.11, LS.3.7.12
Physical science	PS.5.7.2, PS 5.7.5, PS.5.7.7, PS.5.7.8, PS.5.7.9, PS.5.7.10 PS.7.7.1, PS.7.7.2, PS.7.7.4, PS.7.7.5
Earth and space science	ESS.8.7.5, ESS.8.7.6, ESS8.7.7, ESS.8.7.8, ESS.8.7.9, ESS.8.7.10, ESS.8.7.11, ESS.8.7.14, ESS.8.7.15, ESS.8.7.17, ESS.8.7.18, ESS.8.7.19 ESS.8.7.21, ESS.9.7.4, ESS.9.7.5, ESS.10.7.2, ESS.10.7.3, ESS.10.7.4, ESS.10.7.6

APPENDIX E
CONTENT ALIGNMENT FOR GRADE 12

TABLE E1

Alignment of National Assessment of Educational Progress grade 12 science and Arkansas biology standards

NAEP science standards	Arkansas content	Overall rating[a]	Code[b]	Notes
Physical science				
MATTER	***Properties of matter:*** *characteristics of subatomic particles and atomic structure*			
	P12.1: Differences in the physical properties of solids, liquids, and gases are explained by the ways in which the atoms, ions, or molecules of the substances are arranged and the strength of the forces of attraction between the atoms, ions, or molecules.	1		
	P12.2: Electrons, protons, and neutrons are parts of the atom and have measurable properties including mass and, in the case of protons and electrons, charge. The nuclei of atoms are composed of protons and neutrons. A kind of force that is only evident at nuclear distances holds the particles of the nucleus together against the electrical repulsion between the protons.	1		
	P12.3: In the Periodic Table, elements are arranged according to the number of protons (called the atomic number). This organization illustrates commonality and patterns of physical and chemical properties among the elements.	1		
	P12.4: In a neutral atom, the positively charged nucleus is surrounded by the same number of negatively charged electrons. Atoms of an element whose nuclei have different numbers of neutrons are called isotopes.	1		
	Changes in matter: *particulate nature of matter, unique physical characteristics of water, and changes at the atomic and molecular level during chemical changes*			
	P12.5: Changes of state require a transfer of energy. Water has a very high specific heat, meaning it can absorb a large amount of energy while producing only small changes in temperature.	1		

(CONTINUED)

TABLE E1 (CONTINUED)

Alignment of National Assessment of Educational Progress grade 12 science and Arkansas biology standards

	NAEP science standards	Arkansas content	Overall rating[a]	Code[b]	Notes
Physical science					
MATTER	**P12.6:** An atom's electron configuration, particularly of the outermost electrons, determines how the atom can interact with other atoms. The interactions between atoms that hold them together in molecules or between oppositely charged ions are called chemical bonds.		1		
	P12.7: A large number of important reactions involve the transfer of either electrons (oxidation/reduction reactions) or hydrogen ions (acid/base reactions) between reacting ions, molecules, or atoms. In other chemical reactions, atoms interact with one another by sharing electrons to create a bond. An important example is carbon atoms, which can bond to one another in chains, rings, and branching networks to form, along with other kinds of atoms—hydrogen, oxygen, nitrogen, and sulfur—a variety of structures, including synthetic polymers, oils, and the large molecules essential to life.		1		
ENERGY	***Forms of energy*:** *nuclear energy and waves*				
	P12.8: Atoms and molecules that compose matter are in constant motion (translational, rotational, or vibrational).		1		
	P12.9: Energy may be transferred from one object to another during collisions.		1		
	P12.10: Electromagnetic waves are produced by changing the motion of charges or by changing magnetic fields. The energy of electromagnetic waves is transferred to matter in packets. The energy content of the packets is directly proportional to the frequency of the electromagnetic waves.		1		

NAEP science standards		Arkansas content	Overall rating[a]	Code[b]	Notes
Physical science					
ENERGY	**P12.11:** Fission and fusion are reactions involving changes in the nuclei of atoms. Fission is the splitting of a large nucleus into smaller nuclei and particles. Fusion involves joining of two relatively light nuclei at extremely high temperature and pressure. Fusion is the process responsible for the energy of the sun and other stars.		1		
	Energy transfer and conservation: *translational, rotational, and vibrational energy of atoms and molecules, and chemical and nuclear reactions*				
	P12.12: Heating increases the translational, rotational, and vibrational energy of the atoms composing elements and the molecules or ions composing compounds. As the translational energy of the atoms, molecules, or ions increases, the temperature of the matter increases. Heating a sample of a crystalline solid increases the vibrational energy of the atoms, molecules, or ions. When the vibrational energy becomes great enough, the crystalline structure breaks down and the solid melts.			1	
	P12.13: The potential energy of an object on Earth's surface is increased when the object's position is changed from one closer to Earth's surface to one farther from Earth's surface.			1	
	P12.14: Chemical reactions either release energy to the environment (exothermic) or absorb energy from the environment (endothermic).			1	
	P12.15: Nuclear reactions—fission and fusion—convert very small amounts of matter into appreciable amounts of energy.			1	
	P12.16: Total energy is conserved in a closed system.			1	

(CONTINUED)

TABLE E1 (CONTINUED)

Alignment of National Assessment of Educational Progress grade 12 science and Arkansas biology standards

NAEP science standards	Arkansas content	Overall rating[a]	Code[b]	Notes
Physical science				
MOTION	***Motion at the macroscopic level:*** *velocity and acceleration as quantitative descriptions of motion and the representation of linear velocity and acceleration in tables and graphs*			
	P12.17: The motion of an object can be described by its position and velocity as functions of time and by its average speed and average acceleration during intervals of time.	1		
	P12.18: Objects undergo different kinds of motion—translational, rotational, and vibrational.	1		
	Forces affecting motion: *quantitative descriptions of universal gravitational and electric forces, and relationships among force, mass, and acceleration*			
	P12.19: The motion of an object changes only when a net force is applied.	1		
	P12.20: The magnitude of acceleration of an object depends directly on the strength of the net force and inversely on the mass of the object. This relationship ($a=F_{net}/m$) is independent of the nature of the force.	1		
	P12.21: Whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted by the second object back on the first object. In closed systems, momentum is the quantity of motion that is conserved. Conservation of momentum can be used to help validate the relationship $a=F_{net}/m$.	1		
	P12.22: Gravitation is a universal attractive force that each mass exerts on any other mass. The strength of the gravitational force between two masses is proportional to the masses and inversely proportional to the square of the distance between them.	1		

	NAEP science standards	Arkansas content	Overall rating[a]	Code[b]	Notes
Physical science					
MOTION	**P12.23:** Electric force is a universal force that exists between any two charged objects. Opposite charges attract while like charges repel. The strength of the electric force is proportional to the magnitudes of the charges and inversely proportional to the square of the distance between them. Between any two charged particles, the electric force is vastly greater than the gravitational force.		1		
Life science					
STRUCTURES AND FUNCTIONS OF LIVING SYSTEMS	***Organization and Development:*** *basic needs of organisms: the chemical basis of living systems*				
	L12.1: Living systems are made of complex molecules (including carbohydrates, fats, proteins, and nucleic acids) that consist mostly of a few elements, especially carbon, hydrogen, oxygen, nitrogen, and phosphorous.	**MC.1.B.1** Describe the structure and function of the major organic molecules found in living systems: • carbohydrates • proteins • enzymes • lipids • nucleic acids	3		
	L12.2: Cellular processes are carried out by many different types of molecules, mostly proteins. Protein molecules are long, usually folded chains made from combinations of amino-acid molecules. Protein molecules assemble fats and carbohydrates and carry out other cellular functions. The function of each protein molecule depends on its specific sequence of amino acids and the shape of the molecule.	**MC.1.B.2** Describe the relationship between an enzyme and its substrate molecule(s)	2	IC	MC.1.B.2—enzymes are a type of protein that carries out cellular functions AR: Only lists enzyme and its substrate.

(CONTINUED)

TABLE E1 (CONTINUED)

Alignment of National Assessment of Educational Progress grade 12 science and Arkansas biology standards

NAEP science standards		Arkansas content	Overall rating[a]	Code[b]	Notes
Life science					
STRUCTURES AND FUNCTIONS OF LIVING SYSTEMS	**L12.3:** Cellular processes are regulated both internally and externally by environments in which cells exist, including local environments that lead to cell differentiation during the development of multicellular organisms. During the development of complex multicellular organisms, cell differentiation is regulated through the expression of different genes.	**MC.2.B.3** Investigate the properties and importance of water and its significance for life: • surface tension • adhesion • cohesion • polarity • pH	2	IC	MC.2.B.3—you need to know the role of organelles, ribosomes, and cytoskeleton to meet this NAEP standard.
	Matter and energy transformations: *the chemical basis of matter and energy transformation in living systems*				
	L12.4: Plants have the capability (through photosynthesis) to take energy from light to form higher energy sugar molecules containing carbon, hydrogen, and oxygen from lower energy molecules. These sugar molecules can be used to make amino acids and other carbon-containing (organic) molecules and assembled into larger molecules with biological activity (including proteins, DNA, carbohydrates, and fats).	**MC.3.B.4** Describe and model the conversion of light energy to chemical energy by photosynthetic organisms: **light** dependent reactions **light** independent reactions	2	IC	AR: does not specify formation of sugar molecules that contain carbon, hydrogen and oxygen
	L12.5: The chemical elements that make up the molecules of living things pass through food webs and are combined and recombined in different ways. At each link in an ecosystem, some energy is stored in newly made structures, but much is dissipated into the environment as heat. Continual input of energy from sunlight keeps the process going.	**EBR.8.B.3** Diagram the carbon, nitrogen, phosphate, and water cycles in an ecosystem **EBR.8.B.4** Analyze an ecosystem's energy flow through food chains, food webs, and energy pyramids	2	IC	Diagram cycles AR: only states to analyze energy flow through food webs, etc.
	L12.6: As matter cycles and energy flows through different levels of organization of living systems—cells, organs, organisms, communities—and between living systems and the physical environment, chemical elements are recombined in different ways. Each recombination results in storage and dissipation of energy into the environment as heat. Matter and energy are conserved in each change.	**MC.2.B.1** Construct a hierarchy of life from cells to ecosystems **EBR.8.B.3** Diagram the carbon, nitrogen, phosphate, and water cycles in an ecosystem **EBR.8.B.4** Analyze an ecosystem's energy flow through food chains, food webs, and energy pyramids	2	IC	MC.2.B.1—In order to see how energy flows through levels you need to be able to construct a hierarchy. AR: Only states carbon, nitrogen, phosphate and water cycles

NAEP science standards	Arkansas content	Overall rating[a]	Code[b]	Notes
Life science				
STRUCTURES AND FUNCTIONS OF LIVING SYSTEMS	***Interdependence:*** *consequences of interdependence*			
L12.7: Although the interrelationships and interdependence of organisms may generate biological communities in ecosystems that are stable for hundreds or thousands of years, ecosystems always change when climate changes or when one or more new species appear as a result of migration or local evolution. The impact of the human species has major consequences for other species.	**EBR.8.B.5** Identify and predict the factors that control population, including predation, competition, crowding, water, nutrients, and shelter **EBR.8.B.6** Summarize the symbiotic ways in which individuals within a community interact with each other: • commensalism • parasitism • mutualism	2	MD IC	Evolution—migration is implied.
CHANGES IN LIVING SYSTEMS	***Heredity and reproduction:*** *the molecular basis of heredity*			
L12.8: Hereditary information is contained in genes, located in the chromosomes of each cell. A human cell contains many thousands of different genes. One or many genes can determine an inherited trait of an individual, and a single gene can influence more than one trait.	**HE.4.B.4** Examine different modes of inheritance: • sex linkage • codominance • crossing over • incomplete dominance • multiple alleles	2	IC	Very implied.
L12.9: The genetic information encoded in DNA molecules provides instructions for assembling protein molecules. Genes are segments of DNA molecules. Inserting, deleting, or substituting DNA segments can alter genes. An altered gene may be passed on to every cell that develops from it. The resulting features may help, harm, or have little or no effect on the offspring's success in its environment.	**HE.5.B.1** Model the components of a DNA nucleotide and an RNA nucleotide **HE.5.B.4** Describe and model the processes of replication, transcription, and translation **HE.5.B.5** Compare and contrast the different types of mutation events, including point mutation, frameshift mutation, deletion, and inversion **HE.5.B.6** Identify effects of changes brought about by mutations: • beneficial • harmful • neutral	2	IC	AR; Does not refer to genes AR: Lists replication, transciption and translation

(CONTINUED)

TABLE E1 (CONTINUED)

Alignment of National Assessment of Educational Progress grade 12 science and Arkansas biology standards

	NAEP science standards	Arkansas content	Overall rating[a]	Code[b]	Notes
Life science					
CHANGES IN LIVING SYSTEMS	**L12.10:** Sorting and recombination of genes in sexual reproduction results in a great variety of possible gene combinations from the offspring of any two parents.	**HE.4.B.4** Examine different modes of inheritance: • sex linkage • codominance • crossing over • incomplete dominance • multiple alleles **HE.4.B.2** Differentiate among the laws and principles of inheritance: • dominance • segregation • independent assortment	2	IC	AR:Only states analyze the meiotic maintenance of a constant chromosome. Does not mention sorting or variety AR: Lists sex linkage, codominance, crossing over, incomplete dominance, multiple alleles
	Evolution and Diversity: *the mechanisms of evolutionary change and the history of life on Earth*				
	L12.11: Modern ideas about evolution (including natural selection and common descent) provide a scientific explanation for the history of life on Earth as depicted in the fossil record and in the similarities evident within the diversity of existing organisms.	**HE.6.B.1** Compare and contrast Lamarck's explanation of evolution with Darwin's theory of evolution by natural selection **HE.6.B.5** Evaluate evolution in terms of evidence as found in the following: • fossil record • DNA analysis • artificial selection • morphology • embryology • viral evolution • geographic distribution of related species • antibiotic and pesticide resistance in various organisms **HE.6.B.6** Compare the processes of relative dating and radioactive dating to determine the age of fossils	2	IC	HE.6.B.1—When comparing Darwin to Lamarck, you are learning Darwin's "modern" ideas. AR: refers to much more than fossil record, but only in a list
	L12.12: Molecular evidence substantiates the anatomical evidence for evolution and provides additional detail about the sequence in which various lines of descent branched.	**HE.6.B.5** Evaluate evolution in terms of evidence as found in the following: • fossil record • DNA analysis • artificial selection • morphology • embryology • viral evolution • geographic distribution of related species • antibiotic and pesticide resistance in various organisms **HE.6.B.7** Interpret a Cladogram	2	IC	

	NAEP science standards	Arkansas content	Overall rating[a]	Code[b]	Notes
Life science					
CHANGES IN LIVING SYSTEMS	**L12.13:** 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 from environmental pressure of those organisms better able to survive and leave offspring.	**HE.5.B.5** Compare and contrast the different types of mutation events, including point mutation, frameshift mutation, deletion, and inversion **HE.5.B.6** Identify effects of changes brought about by mutations: • beneficial • harmful • neutral **HE.6.B.2** Recognize that evolution involves a change in allele frequencies in a population across successive generations **HE.6.B.3** Analyze the effects of mutations and the resulting variations within a population in terms of natural selection **EBR.9.B.1** Analyze the effects of human population growth and technology on the environment/ biosphere	2	MC IC	AR doesn't state 1, 3 (3) is implied w/ population growth, not technology)
Earth and space science					
EARTH IN SPACE AND TIME	***Objects in the Universe*:** *a vision of the universe*				
	E12.1: The origin of the universe remains one of the greatest questions in science. The "big bang" theory places the origin approximately 13.7 billion years ago when the universe began in a hot, dense state. According to this theory, the universe has been expanding ever since.		1		
	E12.2: Early in the history of the universe, matter, primarily the light atoms hydrogen and helium, clumped together by gravitational attraction to form countless trillions of stars and billions of galaxies.		1		
	E12.3: Stars, like the sun, transform matter into energy in nuclear reactions. When hydrogen nuclei fuse to form helium, a small amount of matter is converted to energy. These and other processes in stars have led to the formation of all the other elements.		1		

(CONTINUED)

TABLE E1 (CONTINUED)

Alignment of National Assessment of Educational Progress grade 12 science and Arkansas biology standards

NAEP science standards		Arkansas content	Overall rating[a]	Code[b]	Notes
Earth and space science					
EARTH IN SPACE AND TIME	***History of Earth:*** *theories about Earth's history*				
	E12.4: Early methods of determining geologic time, such as the use of index fossils and stratigraphic sequences, allowed for the relative dating of geological events. However, absolute dating was impossible until the discovery that certain radioactive isotopes in rocks have known decay rates, making it possible to determine how many years ago a given rock sample formed.		1		
	E12.5: Theories of planet formation and radioactive dating of meteorites and lunar samples have led to the conclusion that the sun, Earth, and the rest of the solar system formed from a nebular cloud of dust and gas 4.6 billion years ago.		1		
	E12.6: Early Earth was very different from today's planet. Evidence for one-celled forms of life—the bacteria—extends back more than 3.5 billion years. The evolution of life caused dramatic changes in the composition of Earth's atmosphere, which did not originally contain molecular oxygen.		1		
	E12.7: Earth's current structure has been influenced by both sporadic and gradual events. Changes caused by violent earthquakes and volcanic eruptions can be observed on a human time scale, but many geological processes, such as the building of mountain chains and shifting of entire continents, take place over hundreds of millions of years.		1		

NAEP science standards	Arkansas content	Overall rating[a]	Code[b]	Notes
Earth and space science				
EARTH STRUCTURES	***Tectonics:*** *the basics of tectonic theory and Earth magnetism*			
	E12.8: Mapping of the Mid-Atlantic Ridge, evidence of sea floor spreading, and subduction provided crucial evidence in support of the theory of plate tectonics. The theory currently explains plate motion as follows: the outward transfer of Earth's internal heat propels the plates comprising Earth's surface across the face of the globe. Plates are pushed apart where magma rises to form mid-ocean ridges, and the edges of plates are pulled back down where Earth materials sink into the crust at deep trenches.	1		
EARTH SYSTEMS	***Energy in earth systems:*** *internal and external sources of energy in Earth systems*			
	E12.9: Earth systems have internal and external sources of energy, both of which create heat. The sun is the major external source of energy. Two primary sources of internal energy are the decay of radioactive isotopes and the gravitational energy from Earth's original formation.	1		
	Climate and Weather: *systems that influence climate*			
	E12.10: Climate is determined by energy transfer from the sun at and near Earth's surface. This energy transfer is influenced by dynamic processes such as cloud cover, atmospheric gases, and Earth's rotation, as well as static conditions such as the positions of mountain ranges and of oceans, seas, and lakes.	1		
	Biogeochemical cycles: *biogeochemical cycles in Earth systems*			
	E12.11: Earth is a system containing essentially a fixed amount of each stable chemical atom or element. Most elements can exist in several different chemical forms. Earth elements move within and between the lithosphere, atmosphere, hydrosphere, and biosphere as part of biogeochemical cycles.	1		

(CONTINUED)

TABLE E1 (CONTINUED)

Alignment of National Assessment of Educational Progress grade 12 science and Arkansas biology standards

NAEP science standards		Arkansas content	Overall rating[a]	Code[b]	Notes
Earth and space science					
EARTH SYSTEMS	**E12.12:** Movement of matter through Earth's systems is driven by Earth's internal and external sources of energy. These movements are often accompanied by a change in the physical and chemical properties of the matter. Carbon, for example, occurs in carbonate rocks such as limestone, in coal and other fossil fuels, in the atmosphere as carbon dioxide gas, in water as dissolved carbon dioxide, and in all organisms as complex molecules that control the chemistry of life.		1		
	E12.13: Natural ecosystems provide an array of basic processes that affect humans. These processes include maintenance of the quality of the atmosphere, generation of soils, control of the hydrologic cycle, disposal of wastes, and recycling of nutrients.		1		

a. Rating is based on a scale of 1 to 3, where 1 indicates that state standards do not address NAEP content statement, 2 that state standards partially address NAEP content statement, and 3 that state standards fully address or exceed NAEP content statement by targeted grade level.

b. Codes are IC (implied content), LG (content covered at a lower grade level), HG (content covered at a higher grade level), MC (more content), and MD (more detailed content). See appendix C for further information.

TABLE E2

Arkansas biology standards not covered by NAEP grade 12 content

Content area	Arkansas biology standards
Molecules and cells	MC.1.B.3, MC.1.B.4 MC.2.B.2, MC.2.B.4, MC.2.B.5, MC.2.B.6, MC.2.B.7, MC.2.B.8, MC.2.B.9, MC.2.B.10, MC.2.B.11 MC.3.B.1, MC.3.B.2, MC.3.B.3, MC.3.B.5
Heredity and evolution	HE.4.B.1, HE.4.B.5, HE.4.B.6 HE.5.B.1, HE.5.B.2, HE.5.B.3 HE.6.B.1, HE.6.B.4
Classification and diversity of life	CDL.7.B.1, CDL.7.B.2, CDL.7.B.3, CDL.7.B.4, CDL.7.B.5 CDL.7.B.6, CDL.7.B.7, CDL.7.B.8, CDL.7.B.9, CDL.7.B.10 CDL.7.B.11, CDL.7.B.12, CDL.7.B.13, CDL.7.B.14, CDL.7.B.15, CDL.7.B.16, CDL.7.B.17, CDL.7.B.18, CDL.7.B.19, CDL.7.B.20, CDL.7.B.21, CDL.7.B.22
Ecology and behavioral relationships	EBR.8.B.1, EBR.8.B.2, EBR.8.B.7, EBR.8.B.8 EBR.9.B.2, EBR.9.B.3
Nature of science	NS.10.B.1, NS.10.B.2, NS.10.B.3, NS.10.B.4 NS.11.B.1, NS.11.B.2, NS.11.B.3, NS.11.B.4, NS.11.B.5, NS.11.B.6 NS.12.B.1, NS.12.B.2, NS.12.B.3, NS.12.B.4, NS.12.B.5, NS.12.B.6, NS.12.B.7 NS.13.B.1, NS.13.B.2, NS.13.B.3 NS.14.B.1, NS.14.B.2, NS.14.B.3, NS.14.B.4 NS.15.B.1

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