OKLAHOMA SCHOOL TESTING PROGRAM

TEST BLUEPRINT AND ITEM SPECIFICATIONS

SCIENCE

2016–2017

GRADE 8

OKLAHOMA STATE DEPARTMENT OF EDUCATION
CHAMPION EXCELLENCE

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Important Note:

The material in the test and item specifications should not be used as a curriculum guide.

OKLAHOMA SCHOOL TESTING PROGRAM
TEST AND ITEM SPECIFICATIONS

Grade 8 Science

Purpose of the Grade 8 Science Assessment

The purpose of the Grade 8 Science test is to measure Oklahoma students' level of proficiency in the discipline of science. On this test, students are required to respond to clusters of items aligned to the assessable eighth-grade science performance expectations (standards) identified in the 2014 Oklahoma Academic Standards for Science (OAS-S). A cluster is either a set of three multiple-choice items linked with a common stimulus or a set of two multiple-choice items and a technology-enhanced item (TE item/TEI) linked with a common stimulus.

All Grade 8 Science test forms will assess a sampling of the performance expectations in each of the reporting categories below. The reporting categories represent the grouping of performance expectations by the three science content domains as laid out in the OAS-S. Note that results for the Grade 8 Science test will be reported at the content domain level, not at the level of individual performance expectations.

Grade 8 Science Reporting Categories and Assessable Performance Expectations from the Oklahoma Academic Standards for Science*

Physical Sciences	Life Sciences	Earth and Space Sciences
· MS-PS1-5 · MS-PS1-6 · MS-PS2-1 · MS-PS2-2 · MS-PS4-1 · MS-PS4-2	· MS-LS1-7 · MS-LS4-1 · MS-LS4-2	· MS-ESS1-4 · MS-ESS2-1 · MS-ESS2-2 · MS-ESS2-3 · MS-ESS3-1 · MS-ESS3-2 · MS-ESS3-4

*Performance expectations MS-PS1-3 and MS-PS4-3 are not listed in the reporting categories because they are not assessed at the state level.

Test Structure, Format, and Scoring

The Grade 8 Science test consists of clusters of items. A cluster is either a set of three multiple-choice items linked with a common stimulus or a set of two multiple-choice items and a technology-enhanced item linked with a common stimulus.

- A cluster stimulus consists of the passages, graphs, models, figures, diagrams, data tables, etc. that students must read and examine to respond to the items in the cluster. The stimulus may be a combination of multiple stimulus elements (e.g., some text plus a diagram and a data table).
- Each multiple-choice item within the cluster is worth one point and is scored as correct or incorrect.
- Each technology-enhanced item is worth two points and is scored as completely correct (two points), partially correct (one point), or incorrect (zero points).
- Items within a cluster are arranged logically, typically with easier and/or less complex items first.

The table below shows the total number of items (in clusters) that students respond to and the total number of points allocated on a test form. Further explanation is provided in the paragraph below the table.

Total Number of Items and Point Values for Grade 8 Science Test

Content Assessment	Total Items	Total Operational Items and Points	Total Field-Test Items
Grade 8 Science	54 items (18 clusters)	45 items (15 clusters) 48 points	9 items (3 clusters)

As shown in the table, the test form for Grade 8 Science contains both operational clusters and field-test clusters. The operational clusters contribute to the student's score; the raw score (number of points earned) is converted to a scaled score to report test results. (Note that because three of the operational clusters contain two multiple-choice items and a technology-enhanced item, rather than three multiple-choice items, the number of operational items and points is not the same.) The field-test clusters do not contribute to the student's score, but the results are used to evaluate new clusters for use in future operational forms. Clusters that have suitable statistics are used to construct operational tests in subsequent years.

Each cluster aligns to a single OAS-S performance expectation (consisting of a Science and Engineering Practice, Disciplinary Core Idea, and Crosscutting Concept). The clusters are also structured to assess a range of skills and knowledge applications within the performance expectation. In this way, the assessment will gather data measuring a breadth and depth of student ability within the performance expectations.

Test Alignment with Oklahoma Academic Standards for Science

The following criteria are used to ensure alignment of the Grade 8 Science test with the performance expectations (standards) in the OAS-S:

1. Range of Knowledge Correspondence

The Grade 8 Science test is constructed so that a minimum of 80% of the performance expectations in each reporting category have at least one corresponding cluster of items in the operational portion of the assessment.

2. Categorical Concurrence

The Grade 8 Science test is constructed so that there are at least 10 score points measuring each reporting category. This number of points is based on the typical psychometric recommendations for a minimum of 10–12 score points needed to produce a reasonably reliable estimate of a student's mastery of the constructs measured.

3. Depth-of-Knowledge Consistency

On the Grade 8 Science test, the items in the clusters require various Depth-of-Knowledge (DOK) levels. Because items in a cluster are structured to assess a range of skills and knowledge applications within a performance expectation, items at DOK levels 1, 2, and 3 are all included on the test.

OKLAHOMA SCHOOL TESTING PROGRAM

TEST BLUEPRINT SCIENCE 2016-2017 GRADE 8

The blueprint describes the content and structure of the operational test and defines the target number of test items by reporting category for the Grade 8 Science assessment.

REPORTING CATEGORIES[1] (OKLAHOMA ACADEMIC STANDARDS FOR SCIENCE)	TARGET NUMBER OF MC ITEMS	TARGET NUMBER OF TE ITEMS[2]	TARGET RANGE OF SCORE POINTS[3] (PERCENTAGE OF TOTAL)	TARGET NUMBER OF CLUSTERS[4]
PHYSICAL SCIENCES MS-PS1-5 MS-PS1-6 MS-PS2-1 MS-PS2-2 MS-PS4-1 MS-PS4-2	14-17	1	16-19 (33-40%)	5-6
LIFE SCIENCES MS-LS1-7 MS-LS4-1 MS-LS4-2	8-11	1	10-13 (21-27%)	3-4
EARTH AND SPACE SCIENCES MS-ESS1-4 MS-ESS2-1 MS-ESS2-2 MS-ESS2-3 MS-ESS3-1 MS-ESS3-2 MS-ESS3-4	17-20	1	19-22 (40-46%)	6-7
TOTAL OPERATIONAL TEST	42	3	100% (48 TOTAL SCORE POINTS)	15

(Please note this blueprint does not include items that may be field-tested.)

[1] Reporting category names are taken from the three content domain names in the OAS-Science.

[2] Technology-enhanced items (TE items/TEIs) may be used to more authentically address some aspects of the performance expectations (PEs). Each TEI will have a value of two score points. At this time, it is expected that each reporting category will include one TEI. More TEIs may possibly be introduced in future operational cycles. For a paper accommodation, the TEIs will be replaced by paired MC items (two linked multiple-choice questions), also worth two score points.

[3] A minimum of 10 points is required to report results for a reporting category for Grade 8 Science.

[4] Performance expectations will be assessed using a cluster-based format: a set of three multiple-choice items linked with a common stimulus or a set of two multiple-choice items and a technology-enhanced item linked with a common stimulus. Each cluster will align to a single performance expectation. The Grade 8 Science operational test will contain a total of 15 clusters.

Depth-of-Knowledge Assessed by Test Items

The Grade 8 Science test will, as closely as possible, reflect the following Depth-of-Knowledge distribution of items within the clusters.

Grade 8 Science Test DOK Distribution	
Depth-of-Knowledge	**Percent of Total Test Points**
Level 1—Recall and Reproduction	5–10%
Level 2—Skills and Concepts	65–75%
Level 3—Strategic Thinking	15–25%

Items within a cluster are structured to assess a range of skill and knowledge applications within a PE. Some parts of the cluster may reflect more routine concepts and skills, and thus require only DOK Level 1 cognition. Other parts of the cluster will reflect more sophisticated use of knowledge and skills, as well as multi-dimensional thinking, and therefore will require DOK Level 2 and DOK Level 3 cognition.

DOK Level 1

Level 1—Recall and Reproduction—is defined as recalling information such as a fact, definition, term, or simple procedure, as well as performing a simple science process or procedure. At Level 1, students supply basic knowledge; plug in numbers to use a simple formula; make simple measurements; or perform a clearly defined, given series of steps. In simple/DOK 1 procedures, the step or steps to follow are already outlined and are very familiar to/routinely performed by students.

Some examples that represent, but do not constitute all, Level 1 performances are

- recognizing or showing the correct representation of a basic scientific concept or relationship in words, diagrams, or simple models.
- performing a routine procedure, such as measuring length.
- identifying basic tools or steps needed for a defined scientific investigation.
- reading data from a graph or stating a simple, obvious pattern from data.
- restating information from scientific text.

DOK Level 2

Level 2—Skills and Concepts—extends the mental processing beyond recalling or reproducing a response at DOK Level 1. The content knowledge and process involved are more complex than in Level 1. Level 2 items often require students to reason and make decisions as to how to approach the question or problem and to plan or consider a series of steps.

Some examples that represent, but do not constitute all, Level 2 performances are

- specifying and explaining the relationship between basic concepts, properties, or variables.
- developing and using a scientific model in basic conceptual interpretations.
- determining/planning a procedure for a scientific investigation according to specified criteria and then performing the investigation.

- asking clarifying questions about a phenomenon, a scientific investigation, or an engineering problem.
- classifying objects or data into logical categories.
- organizing, displaying, comparing, and interpreting data in different graphical forms.
- predicting the outcome of changes in a system, scientific investigations, or other events.

DOK Level 3

Level 3—Strategic Thinking—requires reasoning, planning, using evidence, and using a higher level of thinking than the previous two levels. The cognitive demands of Level 3 are complex and abstract. The complexity does not result only from the fact that there could be multiple answers, a possibility for both Levels 1 and 2, but because the multistep task requires more demanding reasoning. In most instances, requiring students to explain their thinking is at Level 3, while requiring a very simple explanation or a word or two should be at Level 2. An activity that has more than one possible answer and requires students to justify the response they give would most likely be at Level 3.

Some examples that represent, but do not constitute all, Level 3 performances are

- identifying rich research questions and designing investigations for a scientific or an engineering problem, typically with more than one dependent variable.
- developing a scientific model for a complex situation.
- interpreting and drawing conclusions from complex experimental data.
- justifying and providing evidence for explanations of phenomena.
- constructing a scientific argument with a claim, evidence, and scientific reasoning.
- evaluating the merits and limitations of models, investigative designs, scientific arguments, etc.
- using evidence to revise models, explanations, claims, etc.
- solving non-routine science and engineering problems.
- obtaining and combining information from multiple sources to explain or compare scientific issues.

Note that while the DOK levels are presented discretely, the cognitive demands of items really fall along a continuum. Many cognitive processes and their associated action verbs can be classified at different DOK levels depending on the complexity of what students are expected to do. Therefore, relying primarily on verbs to make a DOK assignment is not reliable. For example, the cognitive process of understanding can include clarifying, giving examples, classifying, summarizing, inferring, comparing, making a model, and explaining. The depth of knowledge at which such processes are carried out can vary, however, as shown in the chart.

Example of Cognitive Process Across Various DOK Levels			
Cognitive Process: Understanding	**DOK 1** · Solve a one-step problem · Represent simple relationships in words, pictures, or symbols	**DOK 2** · Specify and explain relationships (e.g., non-examples/ examples; cause-effect) · Make and record observations · Make basic inferences or logical predictions from data/observations · Use models/diagrams to represent or explain concepts	**DOK 3** · Use concepts to solve non-routine problems · Explain, generalize, or connect ideas using supporting evidence · Make and justify claims · Explain thinking when more than one response is possible · Explain phenomena in terms of concepts

References:

- Webb Science Levels of Depth-of-Knowledge: http://facstaff.wcer.wisc.edu/normw/All%20content%20areas%20%20DOK%20levels%2032802.pdf
- Hess Cognitive Rigor Matrix, Science: http://static.pdesas.org/content/documents/M2-activity_2_Handout.pdf

Universal Test Design Considerations

Universal design, as applied to assessments, is a concept that allows the widest possible range of students to participate in assessments and may even reduce the need for accommodations and alternative assessments by expanding access to the tests themselves. In the Oklahoma State Testing Program, modifications have been made to some items to simplify and clarify their instructions and to provide maximum readability, comprehensibility, and legibility. This includes such changes as reduction of language load in content areas other than Reading, increased font size, fewer items per page, and boxed items to assist visual focus. Specifically in the Science tests, the cluster-based design reduces the number of unique stimuli that students must process. The stimuli and items are constructed with clear wording and presentation, and they exclude extraneous information. Additionally, the vocabulary level for the Grade 8 Science test is two grade levels below, except for science content words.

Test Administration Details

Online Administration

During online testing, the items within a cluster will be presented one at a time. The stimulus will appear on the screen with each associated item.

For longer stimuli or items, a scroll bar will be present to allow students to scroll through the text and/or answer choices.

Students may use the embedded scientific calculator or a scientific calculator that meets the current Oklahoma School Testing Program's calculator policy as documented by SDE. (See http://sde.ok.gov/sde/sites/ok.gov.sde/files/CalculatorPolicy16-17.pdf).

No reference sheets/resource materials may be used by students during the Grade 8 Science test. All necessary formulas and information will be provided within the items.

Students will be able to use scratch paper for the online Grade 8 Science test. This paper must be collected and destroyed by the test administrator immediately following the test. The test administrator must not look at what the student has written on the scratch paper.

Paper/Pencil Accommodation

Paper/pencil testing is used only as a testing accommodation. In the paper/pencil test booklet, any technology-enhanced items that appear in the online test form will be replaced by paired multiple-choice items that target the same constructs.

Students may use a scientific calculator that meets the current Oklahoma School Testing Program's calculator policy as documented by SDE. (See http://sde.ok.gov/sde/sites/ok.gov.sde/files/CalculatorPolicy16-17.pdf.)

Scratch paper will not be provided, as scratch work may be done in the test booklet.

Estimated Testing Time

The Grade 8 Science test is divided into two sessions. Districts may exercise flexibility in determining how to administer the sessions. When testing a session, test administrators may give students additional time if they need it, but the additional time is to be given as an extension of that specific testing session.

The following table provides estimates of the time required to administer the Grade 8 Science test by session. These time approximations are provided to facilitate planning administration logistics within schools and to ensure adequate testing time for all students. Actual testing times may vary from these approximations.

Grade 8 Science Estimated Testing Times

Session	Approximate Duration
Directions	10 minutes
Test Session 1	50–60 minutes
Test Session 2	50–60 minutes
Total Testing Time:	**110–130 minutes**

ITEM SPECIFICATIONS

Important Note:

The material in the test and item specifications should not be used as a curriculum guide.

The item specifications provide guidelines and suggestions for the type of content to be included in item clusters, but they do not provide an exhaustive list of what can be included. The cluster stimulus attributes, model item descriptions, and sample item clusters are not intended to be completely definitive in nature or construction—the cluster stimuli and items may differ from one test form to another, as may their presentations.

All item clusters are expected to be of the highest quality and be tightly aligned to the OAS-S. All item clusters developed using these specifications are reviewed by Oklahoma educators and approved by the Oklahoma State Department of Education.

Introduction

The item specifications documentation is intended to provide guidance on the structure and content of the test material developed for the Oklahoma State Testing Program (OSTP) for Grade 8 Science. The Grade 8 performance expectations of the Oklahoma Academic Standards for Science (OAS-S) will be assessed on the Grade 8 Science test using a cluster-based format: a set of three multiple-choice items linked with a common stimulus or a set of two multiple-choice items and a technology-enhanced item linked with a common stimulus.

Functionally, the item specifications documentation represents a bridge between the constructs in the OAS-S, the Oklahoma Science Framework, the test specifications, and the test blueprint for Grade 8 Science. The item specifications delineate core emphases, examples, and boundaries for item clusters written for each OAS-S performance expectation as well as expectations for the format and structure of the cluster stimuli and items. In this way, the item specifications help ensure that the item clusters appearing on the Grade 8 Science test consistently and accurately reflect the constructs in the OAS-S and validly measure students' proficiency in the performance expectations of the OAS-S.

The information utilized for the specifications for each Grade 8 OAS-S performance expectation draws extensively from the OAS-S and from the Oklahoma Science Framework, thus providing a strong link between instruction and assessment. The information in the item specifications is also informed by the tenets in *A Framework for K–12 Science Education*[1] and recognized best practices in assessment (*Standards for Educational and Psychological Testing*[2], *Code of Fair Testing Practices in Education*[3]).

The item specifications are intended to be used by multiple audiences: Oklahoma educators, Oklahoma State Department of Education staff, and testing vendors. The item specifications provide outlines and suggestions for the types of content and presentation that can be utilized in developing the item clusters for the Grade 8 Science test. As such, the item specifications provide all users with information to gauge the types of skills and understandings that students will be asked to demonstrate on the Grade 8 Science test. This information is useful to

1 National Research Council. (2011). *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Committee on a Conceptual Framework for New K–12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

2 American Educational Research Association, American Psychological Association, and National Council on Measurement in Education (2014). *Standards for Educational and Psychological Testing*. Washington, DC: American Educational Research Association.

3 *Code of Fair Testing Practices in Education* (2004). Washington, DC: Joint Committee on Testing Practices.

Oklahoma educators in planning instruction and conducting classroom formative and summative assessment. It is also useful to Oklahoma educators and State Department of Education staff in reviewing and approving item clusters for use on the Grade 8 Science test because it provides a clearly delineated description of the intent of each performance expectation and what item clusters aligned to each performance expectation should measure.

General Cluster Specifications

The Grade 8 performance expectations of the OAS-S will be assessed on the Grade 8 Science test by using a cluster-based format: a set of three multiple-choice items linked with a common stimulus or a set of two multiple-choice items and a technology-enhanced item linked with a common stimulus. The Grade 8 test consists of some clusters containing only multiple-choice items and some clusters containing both multiple-choice and technology-enhanced items.

A cluster requires students to actively use the Science and Engineering Practice of the performance expectation while applying their knowledge of the Crosscutting Concept and drawing on their understanding of the Disciplinary Core Idea to explain a phenomenon or to solve a science/engineering problem.

Cluster Stimulus

A **cluster stimulus** consists of the passages, graphs, models, figures, diagrams, data tables, etc., that students must read and examine in order to respond to the items in the cluster. To meet the intent of the OAS-S, stimuli must represent a variety of topics and scenarios, many of them novel. An individual stimulus may be a combination of multiple stimulus elements (e.g., some text plus a diagram and a data table).

While the specific content and context requirements of a stimulus will vary depending on the performance expectation being assessed (and are outlined in the individual specification for each performance expectation), the following characteristics are necessary for all cluster stimuli:

1. Information in the stimulus is representative of the Science and Engineering Practice, Disciplinary Core Idea, and Crosscutting Concept for a specific performance expectation.
2. The stimulus presents an example of an event, a phenomenon, an observation, an investigation, or a problem that is engaging, realistic, meaningful, and appropriate for Oklahoma students in Grade 8.
3. The stimulus includes a "hook" or driving reason students would want to find out or know more about the example presented, which is aligned with the core emphasis of the performance expectation. When students are given information, data, or an experimental setup to evaluate, they should know the research question and/or purpose of the research when applicable. To avoid increases in reading load, hooks should be brief (1 or 2 sentences). Additionally, hooks should be integral to the item, not gratuitous.
4. The stimulus provides sufficient information (in the form of tables, graphs, text, diagrams, etc.) for the assessment of a specific performance expectation. In other words, the stimulus must supply sufficient information to allow students to engage in the Science and Engineering Practice of the performance expectation in conjunction with the Disciplinary Core Idea and Crosscutting Concept to respond to items.
5. The stimulus information must be necessary, but not conceptually sufficient, for the student response (i.e., students must also utilize their own knowledge of the constructs in the performance expectation to answer the items).
6. The information included within the stimulus must pertain to multiple items. Unique lead information that supports only one item will be placed in the introduction to that

particular item. Extraneous information should be eliminated from the cluster stimulus and from item lead information (i.e., only relevant, concise information is utilized in order to reduce information overload).

7. There is a balance of graphic and textual stimulus materials among the set of clusters for the test form. The pictorial and graphic representations in the stimulus are appropriate for the grade level and performance expectation being assessed. The stimulus (text and graphic elements) is presented on the screen in the layout that best facilitates student accessibility. Scrolling is minimized when possible.
8. The placement of graphic and textual materials within the stimulus follows a logical flow of information. This is facilitated by the use of clear language, transitions, and pointers between text and graphics.
9. The stimulus avoids material or subject matter that might introduce bias or sensitivity issues:
   a. The material is balanced and culturally diverse.
   b. There is a balance of gender and active/passive roles by gender.
   c. The stimulus does not display unfair representations of gender, race, ethnicity, disability, culture, or religion; nor does the stimulus contain elements that are offensive to any such groups.
   d. The content of the stimulus avoids subject matter that might prompt emotional distress on the part of the students.
10. The content of the stimulus is developed and verified using valid and reliable scientific sources for contexts, examples, and data.
11. Permission to use stimuli from copyrighted material is obtained as necessary by the testing vendor.
12. The stimulus supports the development of 6–8 associated items. (While clusters will contain only three items on the operational test, additional items must be field-tested with the stimulus to ensure enough items are available to construct the operational clusters. Items are sometimes rejected after the field test if the performance data for the item do not meet psychometric requirements.)
13. Careful attention is given to the wording, length, and complexity of the stimulus:
    - word count of approximately 50–300 words
    - vocabulary level two grade levels below, except for science content words
    - use of footnotes to define unfamiliar science content words (exception: one-word parentheticals may be used)
    - focus on shorter sentence structure and less complex grammatical constructions
    - consideration of qualitative and quantitative readability measures to review text complexity

Note: The exact vocabulary, word count, and complexity of each stimulus will be reviewed by Oklahoma educators and approved by the Oklahoma State Department of Education to achieve the most appropriate stimulus for each cluster based on the grade level and content being assessed.

Cluster Items

The items within each cluster must work together cohesively to provide a valid measure of the performance expectation being assessed. The following criteria should guide the development of items in each cluster:

1. The items are tied closely to their specific stimulus so that the impact of non-curricular knowledge and experience, while never wholly avoidable, is minimized.
2. The items cover the concepts, information, and evidence that are central to students' understanding of the specific cluster stimulus and are focused on the Science and Engineering Practice, Disciplinary Core Idea, and Crosscutting Concept of the performance expectation. Across an item set it must be clearly evident that students have used all three dimensions of the given performance expectation.
3. The items do not assess Science and Engineering Practices that are not part of the performance expectation that the cluster is aligned to.
4. The items within a cluster address different depths and breadths of understanding of the specific performance expectation. Items are to be written to a range of depths of knowledge, from basic representation and skill applications to strategic thinking and reasoning.
5. The model item stems described in the specifications for each performance expectation are utilized whenever possible. The model item stems represent general ways (and specific ways, in brackets) to assess the multiple dimensions of each performance expectation. The model item stems are not meant to be an exhaustive listing; rather, they represent a selection that can be used with an appropriate stimulus to craft well-aligned items. Other stems may be used in place of these model item stems, but they must capture multiple dimensions such that the finished cluster shows alignment to all three dimensions of the performance expectation.
6. Graphics and information for all cluster items are generally placed in the cluster stimulus, but items may have additional information or graphics when necessary. (Unique lead information supporting only one item will be placed in the introduction to that specific item.) Graphics must be clearly associated with their intended items.
7. Each item in the cluster is independent of the other items; that is, the answer to one item is not required to answer the other items.
8. To the greatest extent possible, no item or answer choice clues the correct answer to any other item.
9. The items in the cluster are presented to the student one at a time online. The stimulus appears on the screen with each item in the cluster.

General Item Writing Mechanics

All items written during the development of the item clusters for the Grade 8 Science test will follow best practices in assessment pertaining to the structure and format of the items per item type. Consideration is also given to vocabulary word choices.

Multiple-Choice Items

- Each multiple-choice item has a stem (formatted as a question or an incomplete statement) and four answer options, only one of which is correct.
- All item stems clearly indicate what is expected in the item to help students focus on selecting a response. The stem presents a complete problem so that students know what to do before looking at the answer choices; students should not need to read all the answer choices before knowing what is expected.
- All multiple-choice options—the correct response and the three distractors—are similar in length and syntax. Students should not be able to rule out an incorrect answer or identify a correct response solely because it looks or sounds different from the other answer choices. Distractors are created so that students reason their way to the correct answer rather than simply identify incorrect responses because of a distractor's obviously inappropriate nature. Distractors should always be plausible (but incorrect) in the context of the item stem.
- Any art within individual items (e.g., additional lead art, graphic options) must be functional and necessary for the item.
- Most item stems are positively worded and avoid the use of the word "not." If a negative is required, the preferred format is "All of the following . . . except."
- The responses "Both of the above," "All of the above," "None of the above," and "Neither of the above" are not used as options.

Technology-Enhanced Items

- Technology-enhanced items should be used to more authentically address some aspects of the OAS-S performance expectations and/or to provide more opportunity for students to construct rather than select their response.
- Interaction types are match, hot-spot, drag-drop, and drop-down. Each technology-enhanced item contains only one interaction type per item.
- For each technology-enhanced item, the interaction type used is that which is the most appropriate and enhancing to the construct to be measured.
- Each technology-enhanced item is structured to contain the question (content) first, followed by directions on how to complete the interaction in that item. Consistent style and language are used in these directions (e.g., "Drag the pictures," "Click the object").
- Each technology-enhanced item is worth two points. Students may earn two, one, or zero points for their response; the scoring rubric will define responses that are completely correct and partially correct based on the skill and understanding being assessed.
- Note that for each technology-enhanced item that is authored, a paired multiple-choice item is also created for the paper accommodation. Each paired multiple-choice item consists of two linked multiple-choice questions and assesses information similar to that in the technology-enhanced item. The paired multiple-choice item, like the technology-enhanced item, is worth two points.

Item Vocabulary

- No single source is available to determine the reading level of various words. Therefore, the appropriateness and difficulty of a word is determined in various ways. Vocabulary is checked in the following: *EDL Core Vocabularies in Reading, Mathematics, Science, and Social Studies*; *Basic Reading Vocabularies*; the *Living Word*; or other reliable readability sources.
- In addition, each vocabulary word must be approved by Oklahoma's Content Review Committee. The committee, composed of Oklahoma educators from across the state, reviews proposed vocabulary in item clusters for grade-level appropriateness.
- Except for science content words, the Grade 8 Science test will have a vocabulary level two grade levels below.
- Unfamiliar science words in stimuli are to be defined using footnotes. The exception to this is single-word definitions, which may be placed in parentheses [e.g., mean (average)].

Overview of Layout of Item Specifications by Performance Expectation

For each OAS-S performance expectation, the item specifications are organized in the following way:

Core Idea Category: Performance Expectation Code[1]

Performance Expectation Code and Text[2]

OAS-S Clarification Statement:[3]

OAS-S Assessment Boundary:[4]

Science & Engineering Practice:[5]	Disciplinary Core Idea:	Crosscutting Concept:

In Lay Terms:[6]

Cluster Clarifications:[7]

Cluster Stimulus Attributes:[8]

Typical stimulus elements:

Possible contexts:

Content and evidence to be included:

Types of student responses that need to be supported:

Allowable Item Types:[9]

Model Item Descriptions for Performance Expectation:[10]

Item Type	DOK	Model Stem	Response Characteristics*
MC			
MC			
MC			
MC			
MC			
MC			
MC			
MC			

*Response options can make use of Student Misconceptions (examples of scientifically incorrect assumptions) related to this performance expectation; references to misconceptions are listed in the link(s) below:[11]

Sample Cluster for Performance Expectation:[12]

1 Core idea category and code for each performance expectation from the OAS-S (e.g., **Earth's Systems: MS-ESS2-1**)

2 Coding and text of the performance expectation from the OAS-S

3 Clarification statement for the performance expectation from the OAS-S

4 Assessment boundary for the performance expectation from the OAS-S

5 Science & Engineering Practice, Disciplinary Core Idea, and Crosscutting Concept that underpin the performance expectation from the OAS-S

6 Description of the basic meaning and intent of the performance expectation in easily understandable terms

7 Additional details, clarifications, and content limits needing to be conveyed

8 Specific information about the typical features of the stimuli for clusters aligned to this performance expectation

9 Item types that may comprise the item clusters

10 Descriptions of possible item stems/starters that could be included in clusters for this performance expectation; i.e., general statements (and/or specific statements, in brackets) of ways to assess each performance expectation are given

11 Common student misconceptions related to the performance expectation, to be used when writing items

12 Example of a cluster for this performance expectation (*will eventually be available for all clusters)

Item Specifications by Performance Expectation

Matter and Its Interactions: MS-PS1-5

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MS-PS1-5. Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.

OAS-S Clarification Statement:
Emphasis is on law of conservation of matter and on physical models or drawings, including digital forms, which represent atoms.

OAS-S Assessment Boundary:
Assessment does not include the use of atomic masses or intermolecular forces.

Science & Engineering Practice:	Disciplinary Core Idea:	Crosscutting Concept:
Developing and Using Models • Develop and use a model to describe unobservable mechanisms.	**PS1.B: Chemical Reactions** • Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. • The total number of each type of atom is conserved, and thus the mass does not change.	**Energy and Matter** • Matter is conserved because atoms are conserved in physical and chemical processes.

In Lay Terms:
During chemical reactions the smallest units of a substance, atoms, rearrange and regroup to produce new substances. During this reaction and rearrangement, all the atoms are accounted for and none are lost. Students should be able to create, describe, interpret, and apply models to show these conservation concepts.

Cluster Clarifications:

- Relevant components that students need to include in the model include the types and numbers of molecules that make up the reactants, and the types and numbers of molecules that make up the products.
- Interactions and relationships that students need to represent, describe, and analyze in the model include (1) the rearrangement of atoms during the reaction, (2) conservation of matter (numbers and types of atoms in the reactants equal the same number and types of atoms in the products), (3) conservation of mass (due to each type of atom having a specific mass, and these atoms being conserved in the reaction).
- Mass, not weight, should be referred to in items. (Note this is for measurement of macro amounts of material/samples; per assessment boundary, items may not address atomic mass.)
- The word "reagent" is above grade level and should not be used.
- Simple chemical equations may be included in items (but students are not responsible for balancing these equations).

Cluster Stimulus Attributes:

Typical stimulus elements:

- text descriptions and/or equations for chemical reactions
- diagrammatic models of reactions (complete or partial)

Possible contexts:

- chemical reactions which are familiar to middle school students within the classroom
- chemical reactions which relate to middle school students' everyday life experiences and observations
- reactions that include simple compounds (no polyatomic ions or complex organic chemicals) which may easily be represented in diagrams and manipulated by students – reactions may include formation/decomposition of simple molecules (e.g., water, hydrogen peroxide, sodium azide); combustion or oxidation reactions (e.g., methane plus oxygen, iron plus oxygen; hydrogen sulfide into sulfur dioxide and water, i.e., acid rain).

Content and evidence to be included: information/descriptions about the chemical reaction(s), and/or reaction models

Types of student responses that need to be supported: creating, completing, and/or improving models of chemical reactions; describing and interpreting these models with the focus on conservation of atoms and mass; predicting using these models

Allowable Item Types:

- MC
- TEI

Model Item Descriptions for MS-PS1-5:

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
1	**MC**	1 or 2 per complexity	Describe the components and/or system that are shown/need to be shown by the model. [What is the system shown by this model?] [According to the model, what happens to the number of oxygen atoms?]	Distractors may contain misinterpretations of the model and its components, particularly tied to misconceptions.
2	**MC**	1 or 2 per complexity	Identify relationships between inputs and outputs of a model. [Based on the model, which statement describes the relationship between total mass before and after a chemical reaction?]	Distractors may contain statements describing an increase or decrease in mass or a mass identical to only one of the reactants.
3	**MC**	2	Use the model to predict the number, mass, or type of inputs or outputs. [Based on the model, how much oxygen will be produced by this reaction?]	Distractors may contain amounts of one reactant or product only, or the amount of the reactant minus one known product.
4	**MC**	2	Complete the model to demonstrate the underlying concept about reactions and conservation of mass. [Which molecule should be added to the model to demonstrate the conservation of mass?]	Distractors may include illustrations of products containing different numbers and configurations of atoms into molecules.
5	**MC**	2 or 3 per complexity	Revise the model to demonstrate the underlying concept about reactions and conservation of mass. [Which change will allow this model to demonstrate conservation of mass (e.g., mass or number of atoms not conserved)?]	Distractors may include changes based on failing to conserve matter, changes based on other misconceptions, or changes that do not correct or improve the model.
6	**MC**	2	Select the best model to describe/represent the conservation of matter. [Which molecular model demonstrates conservation of mass?] [Which model correctly shows what happens to the number and types of atoms during this reaction?] [Which model (of a chemical reaction) and explanation best fit the data from this experiment?]	Distractors may include models that show additional atoms or molecules as reactants or products.
7	**MC**	2	Relate the model to its underlying concept about reactions and conservation of mass. [Which statement explains how this model demonstrates conservation of mass?]	Key should focus on inferring what the model shows and how it demonstrates the big ideas of reactions and conservation of matter. Distractors may include statements that include misconceptions or misinterpretation of the model (e.g., compare total numbers of molecules, not atoms, or total classes of products and reactants).

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
8	**MC**	3	Explain *how* the data fit/support the model (i.e., are evidence for the model). [How does the data collected in this investigation support the model?]	Distractors may include explanations that incorrectly relate the data to the model.
9	**MC**	3	Identify evidence that supports the model. [Which evidence supports this model?]	Distractors may include evidence that is irrelevant or which can serve to reject the model.
10	**TEI**	3	Complete a model for a reaction when given an illustration of the reactants in the correct ratio.	Drag-drop interaction. Correct responses show a product with the appropriate number and type of atoms and molecules. Partial credit would be given for responses that have the appropriate numbers of atoms but not the correct arrangement.
11	**TEI**	3	Create an atomic model of a reaction, referring to a balanced chemical equation.	Drag-drop interaction. Correct responses show the same number and type of atoms in reactant and product, as well as appropriate molecules. Partial credit would be given for responses that show conservation of matter but do not show the correct reactant and/or product molecules.
12	**TEI**	3	Show how a given model will change if the amount of reactants or products is increased proportionally.	Drag-drop interaction. Correct responses show proportional changes to reactants/products, as well as appropriate molecules. Partial credit would be given for responses that show conservation of matter but do not show appropriate amounts of new reactant or product molecules.

*Response options can make use of <u>Student Misconceptions</u> (examples of scientifically incorrect assumptions) related to this performance expectation; references to misconceptions are listed in the link(s) below:

From http://assessment.aaas.org/topics/SC#/:

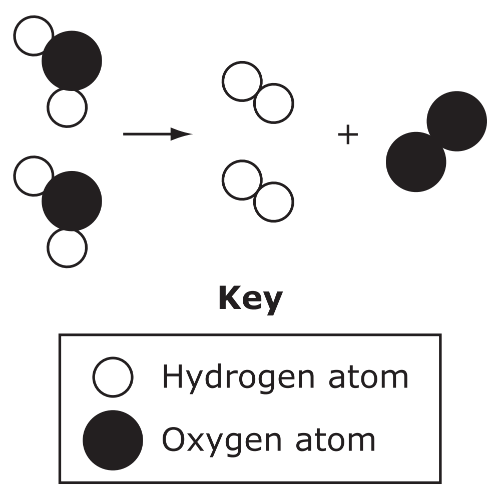
- The atoms of the reactants of a chemical reaction are transformed into other atoms.
- New atoms are created during chemical reactions.
- Atoms can be destroyed during a chemical reaction.
- Everything that exists (including light, energy) is made of matter.
- Matter does not include gases or liquids; gases are weightless.
- Although students may see matter as made of particles, they may not see particles as building blocks of matter.
- If matter is continually subdivided, the pieces will eventually weigh nothing.

Sample Cluster for MS-PS1-5:

Study the information. Then answer questions 1 through 3.

Students were learning about chemical reactions. They learned that there are reactions in which one molecule breaks down into other molecules or atoms, and many of these reactions have useful applications. For example, a chemical called sodium azide (NaN_3) can break down into sodium metal (Na) and nitrogen gas (N_2) inside air bags in cars. The nitrogen gas is what fills the air bag.

As another example, water molecules (H_2O) can break down to form oxygen gas (O_2) and hydrogen gas (H_2). The students wondered how much oxygen gas and hydrogen gas are produced when water breaks down. They wanted to find out if they could predict the amounts based on a model of the reaction. They used the information they had learned to develop a model, as shown.



(Items on the following pages)

1 **What does the students' model show about the relationship between the numbers of atoms present before and after the reaction?**

A The number of oxygen atoms before the reaction is greater than the number of oxygen atoms after the reaction.

B The number of hydrogen atoms before the reaction is greater than the number of hydrogen atoms after the reaction.

C The total number of hydrogen and oxygen atoms before the reaction is equal to the total number of hydrogen and oxygen atoms after the reaction.

D The total number of hydrogen and oxygen atoms before the reaction is less than the total number of the hydrogen and oxygen atoms after the reaction.

Item Type: MC
DOK 1
Key: C

2 The students' teacher asks them to use their model to make a prediction. The students need to predict the total mass of hydrogen gas and oxygen gas produced when 2 grams of water break down.

Based on the students' model, what is the best prediction for the mass of the products of this reaction?

A 2 grams

B 3 grams

C 5 grams

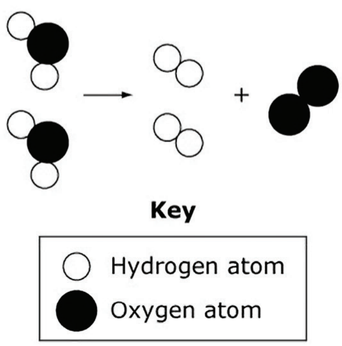
D 6 grams

Item Type: MC
DOK 2
Key: A

3

Students were learning about chemical reactions. They learned that there are reactions in which one molecule breaks down into other molecules or atoms, and many of these reactions have useful applications. For example, a chemical called sodium azide (NaN_3) can break down into sodium metal (Na) and nitrogen gas (N_2) inside air bags in cars. The nitrogen gas is what fills the air bag.

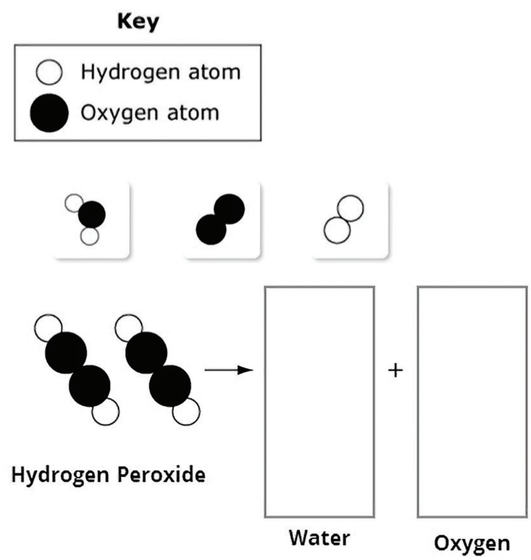
As another example, water molecules (H_2O) can break down to form oxygen gas (O_2) and hydrogen gas (H_2). The students wondered how much oxygen gas and hydrogen gas are produced when water breaks down. They wanted to find out if they could predict the amounts based on a model of the reaction. They used the information they had learned to develop a model, as shown.



Hydrogen peroxide (H_2O_2) is another molecule that can break down into smaller molecules. Hydrogen peroxide breaks down into molecules of liquid water (H_2O) and oxygen gas (O_2).

Create a model that shows what happens to the atoms in hydrogen peroxide when it breaks down to form water and oxygen.

Place the molecules at the top of the model into the boxes to show the correct product molecules when hydrogen peroxide breaks down into water and oxygen gas. To drag a molecule, click and hold the molecule, and then drag it to the desired space. To remove a molecule, click and hold it, and then drag it back to the top. You may use each molecule once, twice, or not at all.



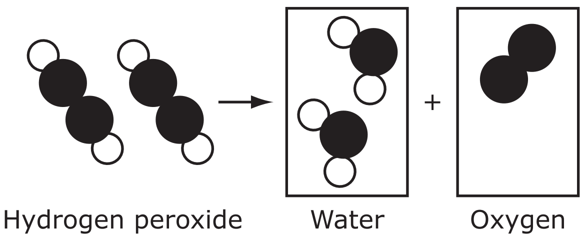
Item Type: TEI
DOK: 3

Scoring:

Rubric

Score	Description
2	A complete answer (2 points) will show two water molecules in the first goal box, and one oxygen molecule in the second goal box.
1	A partial answer (1 point) will show another combination of molecules in which the total number of and type of atoms in the products are equal to the total number and type of atoms in the reactant (e.g., two hydrogen molecules (H_2) under water and two oxygen molecules (O_2) under oxygen).
0	0 pts for fewer to zero correct placements
Blank	

Sample Response



Matter and Its Interactions: MS-PS1-6

back to "Item Specifications by Performance Expectation"

MS-PS1-6. Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.*

OAS-S Clarification Statement:
Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of designs could involve chemical reactions such as dissolving ammonium chloride or calcium chloride.

OAS-S Assessment Boundary:
Assessment is limited to the criteria of amount, time, and temperature of substance in testing the device.

Science & Engineering Practice:	Disciplinary Core Idea:	Crosscutting Concept:
Constructing Explanations and Designing Solutions • Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.	**PS1.B: Chemical Reactions** • Some chemical reactions release energy, others store energy.	**Energy and Matter** • The transfer of energy can be tracked as energy flows through a designed or natural system.

In Lay Terms:
Students should be able to explain how to design, test, modify, or evaluate a device that applies the use of changes in thermal energy resulting from chemical changes.

Cluster Clarifications:
- Do not use the terms exothermic and endothermic (the focus is on the conceptual understanding that energy is absorbed or released and not the terminology).
- Chemical processes should be represented as chemical reactions.
- Devices should have real-life applications that are relevant or accessible to eighth-grade students.
- When possible/appropriate, use common names of chemicals rather than scientific names (e.g., baking soda rather than sodium bicarbonate or sodium hydrogen carbonate).
- Do not use brand names of commercially available devices.
- Criteria and constraints (size, cost, target temperature, time to reach target temperature, etc.) should be a part of the initial design presented to the student, but may or may not be identified as such.
- Designs should be presented within the context of the engineering design cycle.

Cluster Stimulus Attributes:

Typical stimulus elements:
- data tables
- diagrams or models of devices
- diagrams or text descriptions of mechanisms/explanations

Possible contexts:
- making a heat pack or cold pack (exothermic reactions include oxidation of iron, calcium chloride and water, magnesium sulfate and water; endothermic processes include ammonium chloride and water, citric acid and baking soda, vinegar and baking soda, dissolving urea in water)
- MRE (meals-ready-to-eat)
- FRH (flameless ration heaters)
- self-warming sock or glove inserts
- self-warming bandages
- self-cooling tissues
- self-cooling refrigerating elements
- self-cooling beverage can

Content and evidence to be included: comparisons of multiple designs, and/or data tables and diagrams showing components of design

Types of student responses that need to be supported: predicting effect of changing a variable; evaluating a design; modifying a design; making qualitative comparisons of efficiency of energy transfer, diagrams of energy transfer

Allowable Item Types:
- MC
- TEI

Model Item Descriptions for MS-PS1-6:

#	Item Type	DOK	Model Stem (Items ask students to…)	Response Characteristics*
1	**MC**	1 or 2 per complexity	Explain cause-effect relationships or relationships between structures/components in a design. [Which of the following explains how the amount of ammonium chloride affects the rate of cooling in this device?]	Distractors may include statements that do not sufficiently explain, statements that explain alternate phenomena, or statements lacking critical conceptual connections.
2	**MC**	2	Identify the evidence that supports the students' conclusion about a design. [Which data supports the conclusion that design X is most energy efficient?]	Distractors may include data that do not provide sufficient/valid evidence or data related to other processes.
3	**MC**	2 or 3 per complexity	Describe how to modify/change a design to meet a particular design criterion or constraint. [How should the students change their design to increase the rate of cooling?] [Based on the data in the table, which change will increase how quickly the device is able to cool a can of soda?] [Based on the students' results, which combination of chemicals would be most useful to meet the requirements of this device?] [Based on the data in the table, which change should the student make to be sure the cooling device does not freeze the water?] [Based on the data in the table, how should the student change the device so that it can heat 30 g of food to 90°C in ten minutes?] [How should the student change this design to slow down the rate of energy transfer?]	Distractors may include modifications/changes that are irrelevant to a design criterion or which exceed or fail to meet the constraint.
4	**MC**	3	Evaluate different designs to determine which would be the best for a particular goal, or how to incorporate specific strengths of each into a new design. [How should the student combine these designs to create a device that cools most quickly?]	Distractors may include designs that do not achieve a particular goal or which incorporate features that are less effective at meeting the goal.
5	**MC**	2	Relate observations about designs and devices to the idea of energy transfer. [Which of the following observations shows that a device is absorbing energy?]	Distractors may include observations that show energy transfer in a different direction, no transfer of energy, or which are irrelevant to energy transfer.

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
6	**MC**	2 or 3 per complexity	Predict results of a specific action or change based on use of or modifications to a device. [Which graph shows the temperature changes that are likely to result if X grams of ammonium chloride are added to Y grams of water?] [Based on the students' observations, how will grinding the ammonium chloride affect how quickly the cold pack is able to cool the container of water?]	Item and options may be qualitative or quantitative in nature. Distractors may include predictions that contradict results obtained from previous modifications.
7	**MC**	3	Evaluate and/or compare the efficiency of one or more thermal devices. [Based on the diagrams (tracking energy transfer), which device is most efficient?] [Which characteristics of this device make it more energy efficient than the earlier device created by the team?] [Which evidence supports the conclusion that device X is most efficient at transferring energy?]	Distractors may include irrelevant characteristics of the device, irrelevant evidence or incorrect conclusions.
8	**MC**	2 or 3 per complexity	Predict how a given modification (e.g., type/concentration/amount of substance, temperature) will affect the time needed for a thermal device to reach a particular parameter. [How will increasing the amount of ammonium chloride from 1 g to 2 g change how long it takes for the device to cool 100 mL of water?]	Distractors may include predictions that will not affect energy transfer or which will increase/decrease time needed to reach a parameter.
9	**MC**	1 or 2 per complexity	Identify the components of a device that are involved in energy transfer. [Which parts of this device transfer heat from the soda into the environment?] [Which chemicals are absorbing energy in this reaction?]	Distractors may include components which are not involved in energy transfer.
10	**MC**	2	Explain how energy transfer will be tracked when a design is tested. [How should the student measure how energy is transferred in this device?]	Distractors may include incorrect procedures for measuring energy transfer, or unrelated procedures.
11	**MC**	2 or 3 per complexity	Identify or evaluate constraints, which may include amount and cost of materials, safety, and time of functioning. [Which constraints did the students build into this design?] [How well does this design meet the criteria and constraints of the project?]	Distractors may include constraints not built into the design, or characteristics that are not identified in the stimulus as constraints.

*Response options can make use of Student Misconceptions (examples of scientifically incorrect assumptions) related to this performance expectation; references to misconceptions are listed in the link(s) below:

From http://www.rsc.org/eic/2014/05/chemical-energetics-student-misconceptions:

- Energy is used up during chemical reactions.
- Students have difficulty establishing the boundaries of a system.
- Students think that a thermometer is measuring the change of temperature within the system, not of a component within a system.
- Energy is stored within chemicals and released when they react (like releasing the contents of an egg, when cracked; this view causes problems when endothermic reactions are introduced).
- Energy is not required to break bonds.

From http://ac.els-cdn.com/S1877042811001649/1-s2.0-S1877042811001649-main.pdf?_tid=b94f2762-2bd3-11e5-8b27-00000aacb360&acdnat=1437062585_265db3b7648842f443bbf234d4d5b09f:

- Perceptions of hot or cold are unrelated to energy transfer.
- A cold body contains no heat.
- The temperature of an object depends on its size.
- Heat and cold flow like liquids (e.g., if hands become cold it is because cold is flowing into them).
- Temperature can be transferred.
- Hot objects naturally cool down and cold objects naturally warm up.
- Heat flows more slowly through conductors, making them hot.
- The kinetic theory does not really explain heat transfer.
- Hot and cold temperatures are properties of substances (e.g., metal objects are cold, polystyrene objects are room temperature).
- Heat always rises.
- Water cannot be at 0°C.
- Ice is at 0°C and/or cannot change temperature.
- Heat and temperature are the same thing.
- Heat and cold are substances.
- Some materials, like wool, have the ability to warm things up.

From: https://edtechdev.wordpress.com/2010/01/02/misconceptions-about-design/:

- Engineering is a linear process, not one that moves in iterative cycles that revisit past decisions and consider alternate strategies/design pathways.
- Engineering is only about coming up with ideas, not implementing them.
- Engineers can ignore design constraints, to come up with the best design regardless of cost or other factors.
- The first solution to a problem is the best solution.

Motion and Stability: Forces and Interactions: MS-PS2-1

back to "Item Specifications by Performance Expectation"

MS-PS2-1. Apply Newton's third law to design a solution to a problem involving the motion of two colliding objects.*

OAS-S Clarification Statement:
Examples of practical problems could include the impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle.

OAS-S Assessment Boundary:
Assessment is limited to vertical or horizontal interactions in one dimension.

Science & Engineering Practice	Disciplinary Core Idea:	Crosscutting Concept:
Constructing Explanations and Designing Solutions • Apply scientific ideas or principles to design an object, tool, process or system.	**PS2.A: Forces and Motion** • For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law).	**Systems and System Models** • Models can be used to represent systems and their interactions—such as inputs, processes, and outputs—and energy and matter flows within systems.

In Lay Terms:
Students should be able to apply the idea of action-reaction to describe how to modify a device, process, or system involving collision of objects to model this concept, or to evaluate or explain the results of modifications to a system involving colliding objects.

Cluster Clarifications:
- Do not include calculations apart from net force (e.g., momentum).
- Focus is on action-reaction, not Newton's first or second law.
- Students are not responsible for recognizing the name or text of Newton's third law.
- Force diagrams and vectors (showing one-dimensional movement) can be used but do not use the term vector.
- Describe contact forces only (not action at a distance, e.g., gravity).
- Context (stimulus) must clearly present the problem for which the solution is needed.
- Contexts should demonstrate or allow students to conclude/show that a larger action has a larger reaction.

Cluster Stimulus Attributes:

Typical stimulus elements:

- data tables
- diagrams or models of devices
- diagrams or text descriptions of mechanisms/explanations

Possible contexts:

- problems related to football, bike helmets, bumper cars, Roomba vacuum, baseball, pool, water balloons, knee pads while skating, pole vaulters, jousting, gymnastics springboard design, baseball bat (including bats of different masses), shot put, softball
- vehicles of different masses
- toy trains, cars (e.g., how can I reduce the impact forces in a collision between two toy cars?)
- asteroids and meteors colliding with each other or with Earth, space vehicles (e.g., how can NASA use a rocket to move an asteroid off course?)
- designing or modifying a device to keep an egg from breaking
- modifying a Newton's cradle or similar device to ensure a specific result occurs (e.g., how do I make sure 4 balls are set in motion?)

Content and evidence to be included: comparisons of multiple designs, data tables, and diagrams showing components of design

Types of student responses that need to be supported: predicting effect of changing variables; evaluating designs; modifying designs; describing and explaining diagrams of device designs and forces

Allowable Item Types:

- MC
- TEI

Model Item Descriptions for MS-PS2-1:

#	Item Type	DOK	Model Stem (Items ask students to…)	Response Characteristics*
1	**MC**	2	Identify the evidence that supports the students' conclusion about a design. [Which data support the conclusion that Design X will be most effective in reducing damage from a crash?] [Which of the following explains why a heavier bat is more likely to drive the ball a greater distance?]	Distractors may include data that do not provide sufficient/ valid evidence, or data related to other processes.
2	**MC**	2 or 3 per complexity	Describe how to modify a design to meet a particular design criterion or constraint. [How should the students change their design to decrease the movement of car B after a collision?] [Based on the data in the table, which change will decrease the amount of damage to the egg?] [Based on the students' results, which set of changes would be most useful to meet the requirements of this device?] [How would increasing the mass of part X affect the way it interacts with part Y?]	Distractors may include modifications that are irrelevant to a design criterion or which exceed or fail to meet the constraint.
3	**MC**	3	Evaluate different designs to determine which would be the best for a particular goal, or how to incorporate specific strengths of each into a new design. [How should the student combine these designs to create a device that demonstrates the idea of equal and opposite forces on the objects?]	Distractors may include designs that do not achieve a particular goal or which incorporate features that are less effective at meeting the goal.
4	**MC**	2	Relate observations to the idea of energy transfer involving the motion of two colliding objects. [Which of the following observations shows the correct motion of two objects after energy transfer in a collision?]	Distractors may include observations that show motion in an incorrect direction or that describe incorrect action-reaction pairs, or may include observations that are unrelated to action-reaction.
5	**MC**	3	Describe the practical application or value of a design or device incorporating Newton's third law. [Which of the following describes how this design could be applied to a real-life situation?]	Distractors may include irrelevant applications, or applications that do not apply Newton's third law.

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
6	**MC**	2 or 3 per complexity	Predict how a given modification to a model or device will affect how well it meets a design criterion. [How will increasing the mass of car 2 change the net force in this collision?] [How can this device (ruler with track for marbles) be changed so that when two balls are rolled onto the track and collide with balls that are already there, three balls always roll off the track?] [How much force will car 1 exert on car 2?] [Based on the students' previous observations, how will increasing the number of sides on the box affect the likelihood of the egg breaking?] [Based on the data collected, which graph predicts how the speed of a rocket is likely to affect the movement of an asteroid?]	Distractors may include predictions that will not affect the design criterion or which contradict results obtained from previous investigations. Distractors may include responses that misinterpret the relationship between force, mass, and motion or the idea of action-reaction.
7	**MC**	2	Describe the data or processes needed to test the design solution or modification of the design. [What observations and measurements should the students make to test the design solution?]	Distractors may include incorrect descriptions of processes or data.
8	**MC**	2 or 3 per complexity	Identify or evaluate constraints, which may include amount and cost of materials, safety, and time of functioning. [Which constraints did the students build into this design?] [How well does this design meet the criteria and constraints of the project?]	Distractors may include constraints not built into the design, or characteristics that are not identified in the stimulus as constraints.
9	**MC**	2 or 3 per complexity	Explain how a design solution meets a specific criterion. [Which of the following explains why design B is most effective at reducing the damage from a crash?]	Distractors may include explanations that misinterpret the concept of action-reaction, or otherwise misaddress the criterion or design.
10	**MC**	2	Use science concepts to explain why a design does or does not work. [Which of the following best explains why the student's design was unsuccessful at preventing damage to the egg?] [Which of the following explains how the mass of the ball affects its ability to knock down pins?]	Distractors may include statements that do not sufficiently explain; statements that explain alternate phenomena; or statements lacking critical conceptual connections.
11	**MC**	1 or 2 per complexity	Describe the system of interacting parts within a given model for the problem or device. [Which parts of the model are involved in the collision?] [How do parts X and Y demonstrate the idea of action-reaction?] [How does the student's design use the idea of equal and opposite forces on the objects?]	Distractors may include descriptions that incorrectly describe the relationship among force, mass, and motion. Distractors may include components which are not interacting as action-reaction pairs.

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
12	**TEI**	2	Show the predicted behavior of parts of a device or system before, during, or after a collision. [Show the most likely locations of the toy cars after the collision.]	Drag-drop interaction. Correct responses show correct positions or effects for all objects required. Partial credit would be given for a subset of correct responses based on number and/or complexity.

*Response options can make use of Student Misconceptions (examples of scientifically incorrect assumptions) related to this performance expectation; references to misconceptions are listed in the link(s) below:

From: http://newyorkscienceteacher.com/sci/pages/miscon/phy.php:

- If an object is at rest, no forces are acting on the object.

From: http://www.sciepub.com/reference/95496

- An object with a constant (non-zero) net force will have a constant speed.
- Faster moving objects have a larger force acting on them.

From http://www.victoria.ac.nz/physics-resource-centre/resources/mechanics:

- Action-reaction forces balance or cancel each other out. (In reality, forces can only balance when they are on the same object—action-reaction forces are on two different objects.)
- Newton's third law is briefly suspended when motion begins, but then takes over again (in reality motion occurs because forces are not balanced).

From: https://edtechdev.wordpress.com/2010/01/02/misconceptions-about-design/:

- Engineering is a linear process, not one that moves in iterative cycles that revisit past decisions and consider alternate strategies/design pathways.
- Engineering is only about coming up with ideas, not implementing them.
- Engineers can ignore design constraints, to come up with the best design regardless of cost or other factors.
- The first solution is the best solution.

Motion and Stability: Forces and Interactions: MS-PS2-2

back to "Item Specifications by Performance Expectation"

MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

OAS-S Clarification Statement:

Emphasis is on balanced (Newton's first law) and unbalanced forces in a system, qualitative comparisons of forces, mass, and changes in motion (Newton's second law), frame of reference, and specification of units.

OAS-S Assessment Boundary:

Assessment is limited to forces and changes in motion in one dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.

Science & Engineering Practice:	Disciplinary Core Idea:	Crosscutting Concept:
Planning and Carrying Out Investigations • Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.	**PS2.A: Forces and Motion** • The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. • The greater the mass of the object, the greater the force needed to achieve the same change in motion. • For any given object, a larger force causes a larger change in motion.	**Stability and Change** • Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.

In Lay Terms:

Students should be able to describe how to carry out an investigation that helps demonstrate

- the effect of the mass of an object on its motion (the greater the mass, the more force required for a given amount of motion), and/or
- the effect of balanced and unbalanced forces (and the magnitude of the unbalanced force) on an object's motion (the larger the force, the larger the change in motion).

Cluster Clarifications:

- Items may discuss Newton's second law qualitatively, but students are not responsible for quantitative manipulations of the equation $F=ma$ (i.e., items may ask how a change in mass is likely to affect the motion of an object, but students are not responsible for directly explaining the mathematical relationship between force, mass, and acceleration).
- Students are not responsible for identifying Newton's laws by name.
- Do not include gravity or falling of objects on different planets.
- Force diagrams may only show forces in one dimension (i.e., forces applied in the same or opposite directions, not perpendicular or at angles).
- Controlled variables are a part of this performance expectation, but control *groups* are not.
- Context may include multiple investigations, each addressing a different variable, but any data tables should be shown separately to be clear only one variable is to be changed per investigation.

Cluster Stimulus Attributes:

Typical stimulus elements:

- investigation questions
- diagrams and/or text-based descriptions of investigation plans
- (partial) data tables

Possible contexts:

- investigations of lab-based or real-world examples of balanced and unbalanced forces including, but not limited to: use of spring scales to measure forces in same or opposite directions, tug of war, empty versus full shopping cart, linebacker versus kicker, car braking, table tennis ball launcher, air resistance/parachute/feather/falling objects (on Earth)
- identification of the ball or other object with the most appropriate mass for a given purpose, based on investigating the force/mass/motion relationship
- investigations of the relationship among force, mass, and motion
- simulations of balanced and unbalanced forces
- force diagrams within the context of an investigation

Content and evidence to be included: descriptions of problems or phenomena related to the cause of change in motion that is to be investigated, or descriptions of investigations about changes in motion to be evaluated

Types of student responses that need to be supported: describing and/or evaluating proper investigation procedures, tools, measurements, and data that will show the cause of an object's change in motion (mass or force differences)

Allowable Item Types:

- MC
- TEI

Model Item Descriptions for MS-PS2-2:

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
1	**MC**	2	Based on supplied data/observations, identify the phenomenon being investigated.	Distractors may include related phenomena or claims that cannot be investigated with the data or observations supplied.
2	**MC**	2	Describe the data/observations that would support the purpose of an investigation or claim being investigated. [Which of the following observations would provide evidence that motion occurs because of unbalanced forces acting on an object?]	Distractors may include observations or ideas based on misconceptions and incorrect reasoning.
3	**MC**	2	Describe *how* data can be used as evidence of the phenomenon being investigated. [Which statement describes how the data being collected will help the students answer the question (about the cause of a change in an object's motion)?]	Distractors may include incorrect interpretations or applications of the data being collected.
4	**MC**	2	Explain how to measure relevant properties of the object(s) being investigated (e.g., motion, speed, direction), including units where appropriate. [Which tool and unit should students use to measure the force applied to the cart?] [Which statement explains how the students should measure the forces acting on the car?]	Distractors may include incorrect procedures, correct procedures but incorrect units, English (customary) units (mph), or derived units that are written incorrectly (sec/m), or the use of familiar but incorrect or less useful or accurate tools.
5	**MC**	2	Explain how to manipulate or analyze measurements to be collected in an investigation. [Which diagram shows how to calculate net force for the objects studied in this investigation?]	Distractors may include manipulations of inappropriate addends or factors.
6	**MC**	3	Describe the investigation plan that will provide the most useful evidence to answer a given question or support/refute a claim related to changes in forces, mass, and motion. [Which investigation plan should the students use to demonstrate the idea that changes in motion depend on both the mass of an object and the force placed on the object?]	Distractors may include irrelevant procedures or data collection that will be less useful in answering the question or supporting/refuting the claim.

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
7	**MC**	3	Modify an investigation plan to improve the data and evidence to answer a question or support a claim related to changes in force, mass, and motion. [Which of the following shows how to modify the investigation to test whether both mass and force can affect an object's motion?] [How should the students modify their investigation to be more certain of their conclusions?]	Distractors may include modifications which will make the data less useful, or which will add procedures that are irrelevant. This may include increasing the number of trials while introducing uncontrolled variables; limiting uncontrolled variables while also decreasing the number of trials; or increasing the amount of data collected while reducing the number of trials for each factor tested.
8	**MC**	2	Identify independent, dependent, and/or controlled variables in an investigation related to differences in the scale of forces or changes in force, mass, motion. [In this investigation, what is the independent variable?] [What is a variable the students should control to improve this investigation?]	Distractors may include other variable or factors, including variables that are already controlled.
9	**MC**	3	Explain what the data are expected to show. [What should the data collected in this investigation reveal about the relationship between mass and changes of motion?]	Distractors may include statements that reveal an incorrect understanding of the question or claim being studied.
10	**TEI**	2 or 3 per complexity	Complete the diagram to show an investigation setup that will test the question or claim described. [Complete the diagram to show the direction and strength of the forces that should be used in this investigation.]	Drag-drop interaction. Draggable objects and goal boxes should include not only the correct parts but also parts that would show incorrect understanding (e.g., for a force diagram, arrows of different size and direction and goal areas to represent different locations relative to the object being studied). Correct responses place all required components into correct locations. Partial credit would be given for a subset of correct responses.

*Response options can make use of Student Misconceptions (examples of scientifically incorrect assumptions) related to this performance expectation; references to misconceptions are listed in the link(s) below:

From http://newyorkscienceteacher.com/sci/pages/miscon/phy.php:

- The terms "energy" and "force" are interchangeable.
- An object at rest has no energy.
- If an object is at rest, no forces are acting on the object.

http://www.sciepub.com/reference/95496:

- An object with a constant (non-zero) net force will have a constant speed.
- Faster moving objects have a larger force acting on them.

From Molecules to Organisms: Structure and Processes: MS-PS4-1

back to "Item Specifications by Performance Expectation"

MS-PS4-1. Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.

OAS-S Clarification Statement:

Emphasis is on describing waves with both qualitative and quantitative thinking.

OAS-S Assessment Boundary:

Assessment does not include electromagnetic waves and is limited to standard repeating waves.

Science & Engineering Practice:	Disciplinary Core Idea:	Crosscutting Concept:
Using Mathematics and Computational Thinking • Use mathematical representations to describe and/or support scientific conclusions and design solutions.	**PS4.A: Wave Properties** • A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.	**Patterns** • Graphs and charts can be used to identify patterns in data.

In Lay Terms:

Students should be able to use mathematical representations (e.g., graphs and charts) to demonstrate qualitatively and quantitatively that

- a wave has characteristic properties,
- each wave has a repeating pattern of wavelengths, frequency, and amplitude, and/or
- there is a relationship between the amount of energy transferred by a wave and the wave's characteristics.

Cluster Clarifications:

- The stimulus should involve a physical system or phenomenon, so that the mathematic representation/model is applied to something real (actual utility).
- Wave characteristics that should be focused on are wavelength, frequency, and amplitude, as listed in DCI. Minimize extension to other wave features like crest, trough, etc.
- Students should not be assessed on the concept or calculation of wave speed.
- Descriptions of relationships among wave characteristics should be textual statements of relationships or graphical displays, not equations.
- Information may be quantitative and/or qualitative (e.g., as energy increases, amplitude increases).
- Students should know that volume corresponds to amplitude, that frequency corresponds to pitch, and that amplitude is related to energy.
- Seismic waves may be used as examples; however, students are not responsible for knowing the names or characteristics of these waves (e.g., surface [Rayleigh and Love] waves, body waves including secondary or s-waves, compression, primary or p-waves).
- When representing radio or television frequencies, write out frequency (e.g., 50,000 cycles per second rather than 5 KHz or 5×10^4 KHz).

Cluster Stimulus Attributes:

Typical stimulus elements:

- graphs
- diagrams
- text descriptions
- tables showing amplitude, frequency, speed, and/or wavelength, plus energy

Possible contexts:

- waves that are familiar to middle school students within the classroom, including but not limited to seismic waves, ocean waves
- models of sound waves (toy ropes, slinky, or balls showing compression)
- devices that can make sound, such as bottles, rubber bands, radio stations, etc.

Content and evidence to be included: graphs, tables, or other relevant information about waves

Types of student responses that need to be supported: displaying and describing relationships seen in models/graphs of waves; explaining and predicting wave characteristics using the models/graphs

Allowable Item Types:

- MC
- TEI

Model Item Descriptions for MS-PS4-1:

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
1	**MC**	1	Compare the energy, frequency, wavelength, and/or amplitude of waves shown as a drawing or graph. [Which of the following waves has the greatest frequency?] [Which diagram shows the wave with the longest wavelength?]	Distractors may contain graphs or diagrams showing different wave characteristics.
2	**MC**	1 or 2 per complexity	Identify where or how the wavelength, frequency, and/or amplitude of a wave is represented in a graph or diagram. [Which diagram shows how to measure the amplitude of the wave shown in the graph?] [What is the wavelength of the wave shown in the diagram?]	Distractors may contain ways to measure other characteristics of waves, or incorrect procedures to make these measurements.
3	**TEI**	2	Show where or how the wavelength, frequency, and/or amplitude of a wave is represented in a graph or diagram. [Label the wavelength and amplitude of the graph (by dragging the labels).]	TEI interaction could be drag-drop, drop-down, or match to label parts of the graph or diagram. Correct responses show all parts correctly matched or labeled. Partial credit would be given for having some correct labels identified.
4	**MC**	3	Analyze diagrams of waves with different characteristics to determine which of several waves has the most energy. [Which of the waves shown has the greatest amount of energy?] [Which of the waves shown will be able to transfer the most energy when it hits the shore?] [Which of the waves shown will cause the most damage to a nearby building?]	Distractors may contain waves of different amplitude, wavelength, and frequency.
5	**MC**	3	Compare graphs or diagrams showing changes in mechanical wave characteristics including amplitude, wavelength, frequency, or velocity to select which change will produce changes in energy. [Which of the changes will result in the biggest increase in the energy of the wave?] [How will the energy of this wave change if its amplitude increases to 2 meters?]	Distractors may contain wave pairs showing different combinations of amplitude, frequency, and wavelength.

#	Item Type	DOK	Model Stem (Items ask students to…)	Response Characteristics*
6	**MC**	2	Transform data into graphic representations of waves. [Which graph/drawing best represents the sound wave data shown in the table?]	Distractors may contain graphs misrepresenting the data, showing it as other wave properties (e.g., representing wavelength as frequency, etc.).
7	**MC**	2	Using the model, predict the change in the wave graph or traits of the model, based on a change in the system/ phenomenon. [How would the graph change if the speed of the phenomenon (e.g., vibration) increased?]	Distractors may contain changes and representations that concentrate on a different wave property than the one affected, or that reflect misconceptions.
8	**MC**	2 or 3 per complexity	Explain the reason for a particular difference in the characteristics of waves. [The diagrams shown represent the voice of a person in two different situations. How has the person changed their voice to create the pattern shown in graph 2?] [Which of the following explains why the frequency of these two waves differs?]	Distractors may include causes of changes in other characteristics of waves such as pitch, volume, etc.
9	**MC**	1 or 2 per complexity	Describe a relationship about waves or their properties based on data. [How does the energy of this wave change when its amplitude is doubled?]	Distractors may contain incorrect relationships related to misconceptions or incorrect interpretations of the data.
10	**MC**	2	Identify the graph that shows the higher pitch/volume. [Which of the following graphs shows an increase in the pitch of the voice?]	Distractors may contain changes to the other wave characteristics.
11	**MC**	3	Evaluate how well a model represents a given wave phenomenon (and explain why). [Which model is most useful to represent a sound wave?]	Distractors may include models that represent only a portion of characteristics of the wave phenomenon.
12	**TEI**	2	Match real life properties of phenomena to graphic representations. [Match the station frequency and volume shown for each radio to the correct graph.]	Match interaction. Correct responses show all radio station descriptors matched to the correct graph for that wave broadcast. Partial credit would be given for a subset of correct matches.

*Response options can make use of Student Misconceptions (examples of scientifically incorrect assumptions) related to this performance expectation; references to misconceptions are listed in the link(s) below:

From Conceptual Curriculum for Physics. National Science Foundation. 16 07 2009. http://phys.udallas.edu/C3P/Preconceptions.pdf:

- Waves transport matter.
- Waves do not have energy.
- Big waves travel faster than small waves in the same medium.
- All waves travel the same way.
- Frequency is connected to loudness for all amplitudes.
- Pitch is related to intensity.

From Hapkiewics, A. (1992) Finding a List of Science Misconceptions. MSTA Newsletter, 38 (Winter '92) pp11-14. http://www.cosee-west.org/Dec0410/wave_misconceptions.pdf:

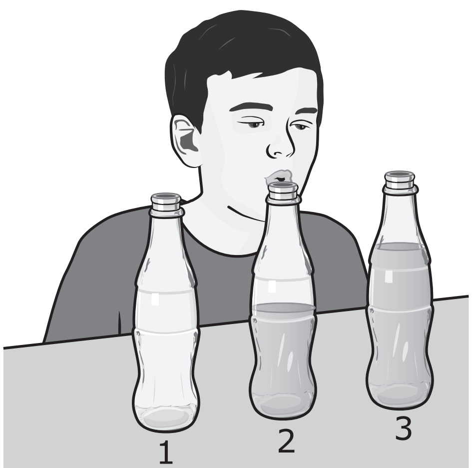
- Sound can be produced without using any material objects.
- Hitting an object harder changes the pitch of the sound produced.
- Loudness and pitch of sounds are the same thing.
- Sounds cannot travel through liquids and solids.
- In wind instruments, the instrument itself vibrates (not the internal air column).
- Matter moves along with water waves as the waves move through a body of water.
- When waves interact with a solid surface, the waves are destroyed.

Study the information. Then answer questions 1-3.

Some students in the middle school band wondered how their instruments make different sounds. They did some investigations to find out more about sound waves, their patterns, and how to model them.

In the first investigation, one student filled three bottles with different amounts of water. The student blew across the top of each bottle. He made sure his breath was the same each time. He listened to the pitch of the sounds.

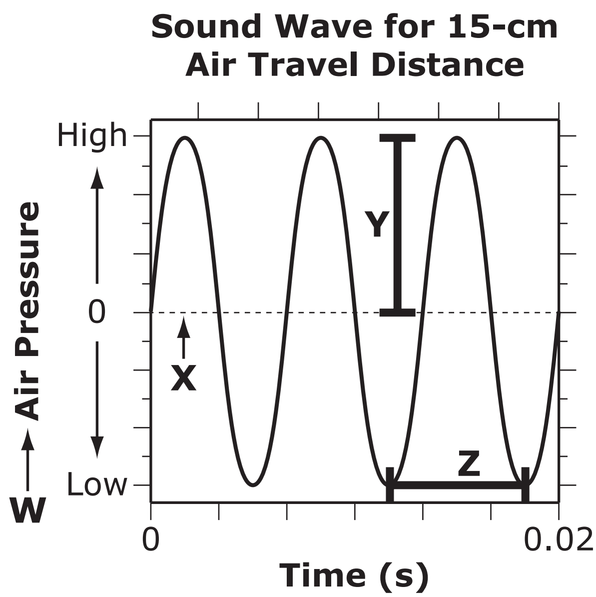
The picture shows how the student set up the bottles. The data table shows the results. The measurement for "Distance Air Travels" is how far air can travel from the top opening down into the bottle.



Sound Investigation Data

Bottle Number	Distance Air Travels (cm)	Pitch
1	20	low
2	10	medium
3	5	high

Next, students used data they found on the internet to make a sound wave graph. Their graph shows the air pressure and frequency of the sound wave made by air vibrating in a bottle during 2/100 of a second. They found data for air blown into the same size bottle they used in their investigation. The data showed the frequency the sound wave created when the bottle was filled with water so that the air travelled 15 cm from the top of the bottle. The students labeled their graph as shown.



(Items on the following pages)

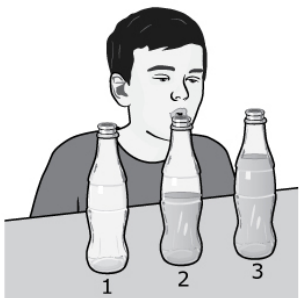
1

Question 1

Some students in the middle school band wondered how their instruments make different sounds. They did some investigations to find out more about sound waves, their patterns, and how to model them.

In the first investigation, one student filled three bottles with different amounts of water. The student blew across the top of each bottle. He made sure his breath was the same each time. He listened to the pitch of the sounds.

The picture shows how the student set up the bottles. The data table shows the results. The measurement for "Distance Air Travels" is how far air can travel from the top opening down into the bottle.



Sound Investigation Data

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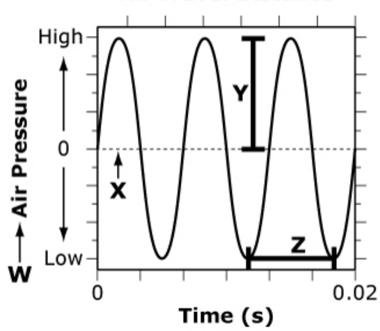
Next, students used data they found on the internet to make a sound wave graph. Their graph shows the air pressure and frequency of the sound wave made by air vibrating in a bottle during 2/100 of a second. They found data for air blown into the same size bottle they used in their investigation. The data showed the frequency the sound wave created when the bottle was filled with water so that the air travelled 15 cm from the top of the bottle. The students labeled their graph as shown.

Sound Wave for 15-cm Air Travel Distance



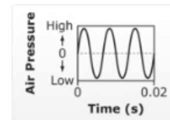
Based on the students' graph, determine the sound wave graph that best represents the sounds made by bottles 1, 2, and 3 in the students' investigation. To match the bottle number on the left with the graph on the right that best represents its sound wave, click the bottle number and then the graph, and a line will automatically be drawn between them. To remove a connection, hold the pointer over the line until it turns red, and then click the line. Each bottle matches only one graph.

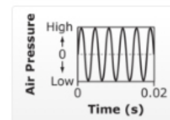
Bottle Number

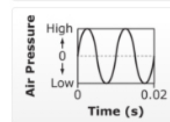
1

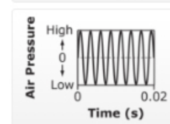
2

3









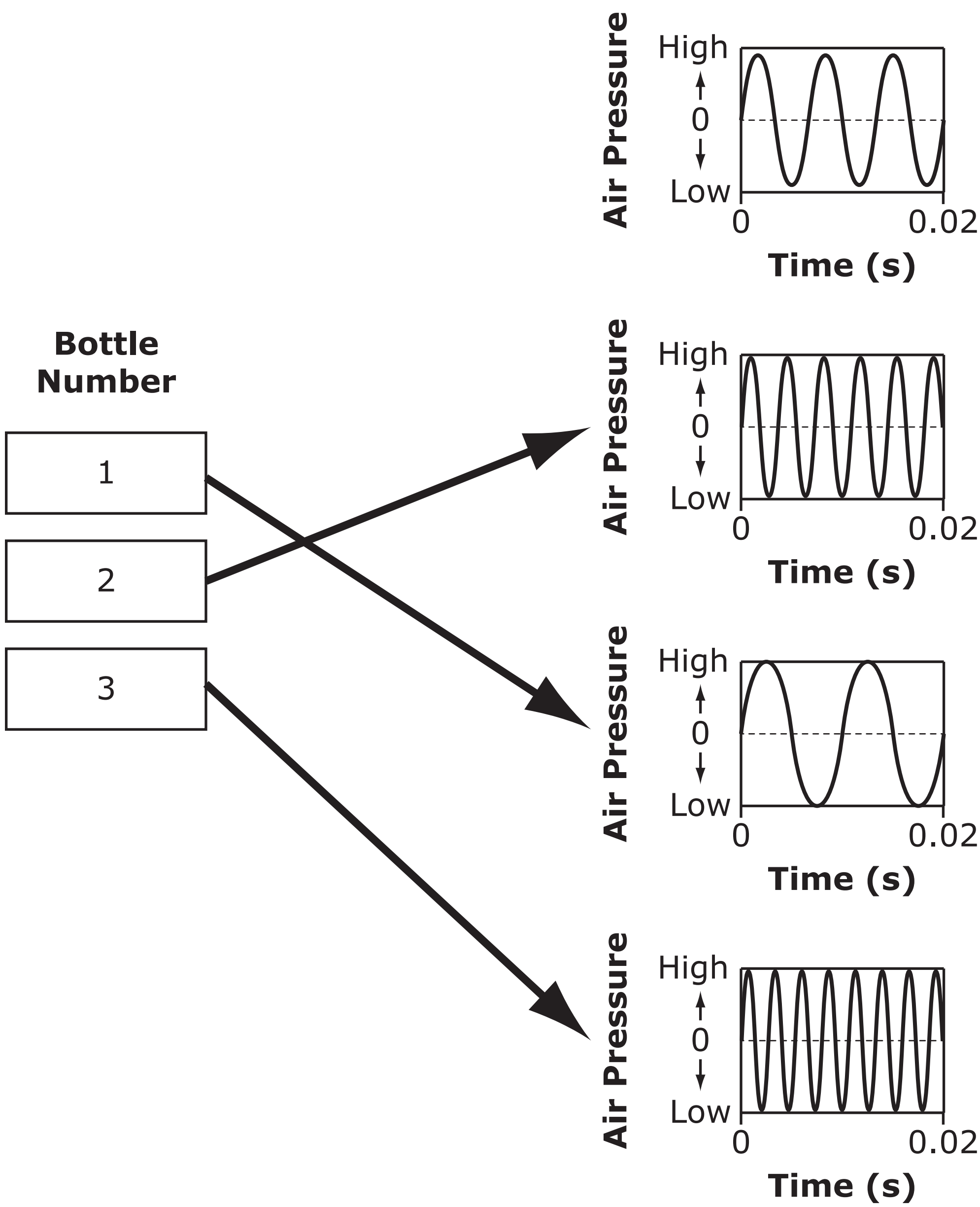
Item Type: TEI
DOK: 2

Scoring:

Rubric

Score	Description
2	Three correct matches
1	Two correct matches with one incorrect or blank
0	One or zero correct matches with one or two incorrect matches or blanks
Blank	

Sample Response



2 **How will the sound wave graph change if the student blows with more force on a bottle to make the sound louder?**

A W values will increase

B X will change positions

C Y distance will decrease

D Z distance will decrease

Item Type: MC
DOK: 1
Key: A

3 **Which statement best explains why the students' model changes even though air is blown in the exact same way into bottles 1, 2, and 3?**

A W increases as the amount of air in each bottle increases.

B X has a different position in each of the bottles.

C Y increases as the size of the bottle changes.

D Z decreases as the vibration rate of air particles in each bottle increases.

Item Type: MC
DOK: 3
Key: D

Waves and Their Applications in Technologies for Information Transfer: MS-PS4-2

back to "Item Specifications by Performance Expectation"

MS-PS4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

OAS-S Clarification Statement:
Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.

OAS-S Assessment Boundary:
Assessment is limited to qualitative applications pertaining to light and mechanical waves.

Science & Engineering Practice:	Disciplinary Core Idea:	Crosscutting Concept:
Developing and Using Models • Develop and use a model to describe phenomena.	**PS4.A: Wave Properties** • A sound wave needs a medium through which it is transmitted. **PS4.B: Electromagnetic Radiation** • When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. • The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. • A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. However, because light can travel through space, it cannot be a matter wave, like sound or water waves.	**Structure and Function** • Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.

In Lay Terms:
Students should be able to create, describe, interpret, and apply models of phenomena involving the movement of mechanical or light waves to describe the interaction of waves with different materials.

Cluster Clarifications:

- Relevant components that students need to include in the model are the wave (matter wave or light wave and its characteristics), the materials the wave will interact with, the new characteristics of the wave after interaction, and the wave source and its position.
- Interactions and relationships that students need to represent, describe, and analyze in the model include (1) wave interactions (reflection, absorption, transmission), (2) the pathway of light (i.e., light travels in straight lines but its path is bent at the interface of materials), (3) whether the wave requires a material to travel (i.e., light can travel through space but matter waves require a material), (4) the way that waves' behavior explains observed phenomena, and (5) why certain materials are well-suited for particular functions based on the way that light or matter waves interact with them (e.g., mirrors, sound absorbers, light filters).
- Mathematics related to Snell's law (refraction) is above grade level.
- Students are responsible for describing the law of reflection in qualitative terms (not quantitative measurements). Students are not responsible for identifying the law of reflection by name.
- Students are not responsible for understanding the mechanics of the perception of color, eye anatomy, diffraction, movement of light through convex or concave mirrors or lenses, or for electromagnetic waves outside of the visible light spectrum.
- The characteristics of waves (amplitude, wavelength, energy, etc.) are addressed in MS-PS4-1, not this performance expectation. Note, however, that frequency as related to color of light is assessable (see DCI).
- Contexts should be grade appropriate and do not include devices/apparatuses seen in high school physics classrooms such as wave tanks.

Cluster Stimulus Attributes:

Typical stimulus elements:

- text descriptions of observations and phenomena for waves
- partial or complete diagrams showing interaction of light waves or mechanical waves with objects

Possible contexts:

- waves of light or lasers reflecting off a wall or mirror
- interaction of light with colored objects
- prisms
- movement of light through air into water/oil
- interaction of sound waves with materials
- echoes, sonar, radar
- pitch (jars with levels or densities of solution)
- motion of light versus sound in space

Content and evidence to be included: descriptions of phenomena involving light and sound waves, and/or models of sound and light wave interactions/behavior

Types of student responses that need to be supported: creating, completing, and/or improving models that illustrate the various behaviors of waves (reflection, absorption, transmission); describing and interpreting wave behavior using their models; predicting wave behavior using their models

Allowable Item Types:

- MC
- TEI

Model Item Descriptions for MS-PS4-2:

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
1	**MC**	1 or 2 per complexity	Describe the components and/or system shown in a model. [What behaviors of light are shown in the model?] [What are some of the components that should be included in the model of the sound wave being reflected?] [What system is shown by this model?]	Distractors may include misinterpretations of the model and its components, particularly tied to misconceptions.
2	**MC**	1	Describe the purpose of a model.	Distractors may contain misinterpretations of the model and its components, particularly tied to misconceptions.
3	**MC**	1 or 2 per complexity	Identify relationships between inputs and outputs of the model and/or roles of components according to the model. [Based on the model, which statement describes the relationship between angle of incidence and angle of reflection for the wave shown?] [What effect does the medium have on the refraction of the light wave?]	Distractors may contain statements describing an incorrect role or relationship, particularly tied to misconceptions.
4	**MC**	2	Complete the model to demonstrate wave behavior in various materials. *or* Identify a missing component of the model or something that should be added to the model. [Which arrow should be added to the model to represent how reflection occurs?] [What should be added to the model to show how the path of light can be changed by different transparent materials?]	Distractors may include illustrations or descriptions representing incorrect understanding of the underlying phenomenon.
5	**MC**	3	Revise the model to demonstrate an underlying concept about wave behavior in various materials. [Which change will allow this model to (better) demonstrate the law of reflection?] [A student has drawn a model of a periscope to demonstrate the law of reflection. How should the student modify this model so that the object shown can be seen by the periscope user?]	Distractors may include descriptions of changes that show an incorrect understanding of the underlying concept, or that do not correct or improve the model representation.

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
6	**MC**	2 or 3 per complexity	Identify the best model to describe the given wave phenomenon. [Which model shows how this game/tool/device uses the law of reflection?] [Which model (of an echo) and explanation best fit the data from this experiment?] [Which model (of movement of light through different liquids) and explanation best fit the data from this experiment?]	Distractors may include models that show an incorrect or incomplete understanding of the phenomenon, process, or relationship.
7	**MC**	2	Relate the model to its underlying concept about wave behavior. [How does this model demonstrate that light waves can move through some materials?] [How can sound waves be used to locate objects according to this model?]	Key should focus on inferring what the model shows and how it links to/explains the observed wave behaviors as a result of the way the waves travel and interact with matter. Distractors may include statements that confuse movement of sound and light, or confuse reflection, transmission, and absorption of light.
8	**MC**	3	Explain *how* the data fit/support the model (i.e., are evidence for the model). [A model showing absorption and reflection of different colors of light by leaves is shown. How do the data collected in this investigation support the model?]	Distractors may include explanations that incorporate possible misconceptions about the phenomenon addressed by the model, or that incorrectly associate data and specific components of the model.
9	**MC**	3	Identify evidence that supports the model. [Which evidence would support this model?]	Distractors may include evidence that is irrelevant or which could be used to reject the model.
10	**TEI**	3	Create/complete a model of a device or structure that applies the properties of sound or light waves. [Complete the model showing reflection and absorption of light interacting with a red cloth (by dragging the words and arrows provided).]	Drag-drop interaction. A minimum of three and maximum of four correct associations should be used. Distractor choices may be incorrect associations that include characteristics that do not apply to the phenomenon described. Correct responses show all labels placed appropriately. Partial credit would be given for a subset of correct labels.

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
11	**TEI**	3	Create/complete a model of the movement of sound or light. [Complete the model showing the movement of sound to produce an echo (by dragging the words and symbols provided).]	Drag-drop interaction. A minimum of three and maximum of four correct associations should be used. Distractors may be incorrect associations that include characteristics that do not apply to the phenomenon described. Correct responses show all labels placed appropriately. Partial credit would be given for a subset of correct labels.
12	**MC**	3	Based on the model, describe the best material to use to produce a given effect. [Based on the model and data table, which material should a wall be made of to allow cell phones to be used in the building?]	Distractors include materials described in data table which will not allow the given effect.
13	**MC**	3	Predict how the wave behavior or result will change if characteristics of inputs are changed. [How will the movement of sound change if the walls of the chamber are replaced with foam?]	Distractors may include predictions that show a misunderstanding of the interactions of the components of the model.
14	**TEI**	3	Show how a given model will change if the characteristics of inputs are changed.	Drag-drop interaction. Distractors may include changes that are not appropriate to the change in input described. A minimum of three and maximum of four correct associations should be used. Correct responses show proportional changes to outputs. Partial credit would be given for outputs that were correct based on type, but were not in proportion.

*Response options can make use of Student Misconceptions (examples of scientifically incorrect assumptions) related to this performance expectation; references to misconceptions are listed in the link(s) below:

From Conceptual Curriculum for Physics. National Science Foundation, 16 07 2009. http://phys.udallas.edu/C3P/Preconceptions.pdf:

- Waves transport matter.
- There must be a medium for a wave to travel through.
- Waves do not have energy.
- Big waves travel faster than small waves in the same medium.
- Different colors of light are different types of waves.
- Pitch is related to intensity or loudness.
- Sound travels at the same speed in all media.
- Wave speed and frequency are the same thing.
- Light "just is" and has no origin.
- Light is a particle.
- The addition of all colors yields black.
- Light is a mixture of particles and waves.
- In refraction, the characteristics of light change.
- There is no interaction between light and matter.

From http://www.cosee-west.org/Dec0410/wave_misconceptions.pdf:

- Students may reject the idea that objects other than mirrors can reflect light.
- There is no association between movement or vibration and the objects producing a sound.
- Vibrations and the sound produced by vibrations are the same thing.
- Sound causes vibrations.
- Sound requires an absence of a medium to travel (this is connected to students' ideas that air is empty and not made of matter).
- Sound can only travel along an unimpeded path.
- Sound moves through holes and cracks in media.
- Sounds distorts as it moves through narrow openings.
- Students represent sound as happening once, as a discrete entity that moves toward receiver, or as a continuous line from source to receiver.

From http://www.nuffieldfoundation.org/sites/default/files/files/SPACE_Report_-_Sound.pdf:

- Echo is a sound repeating itself.

From Hapkiewicz, A. (1992). Finding a List of Science Misconceptions. MSTA Newsletter, 38(Winter'92), pp.11-14. http://www.cosee-west.org/Dec0410/wave_misconceptions.pdf:

- Sounds cannot travel through liquids and solids.

From Molecules to Organisms: Structure and Processes: MS-LS1-7

back to "Item Specifications by Performance Expectation"

MS-LS1-7. Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.

OAS-S Clarification Statement:

Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released.

OAS-S Assessment Boundary:

Assessment does not include details of the chemical reactions for photosynthesis or respiration.

Science & Engineering Practice:	Disciplinary Core Idea:	Crosscutting Concept:
Developing and Using Models • Develop a model to describe unobservable mechanisms.	**LS1.C: Organization for Matter and Energy Flow in Organisms** • Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy. **PS3.D: Energy in Chemical Processes and Everyday Life** • Cellular respiration in plants and animals involves chemical reactions that release stored energy. In these processes complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials *(secondary to MS-LS1-7)*.	**Energy and Matter** • Matter is conserved because atoms are conserved in physical and chemical processes.

In Lay Terms:

Students should be able to identify, complete, and describe components and relationships for a model (i.e., develop a model) to show that the energy required by organisms is released during the breakdown and rearrangement of food molecules, and that the molecules created in this process support growth and life processes.

Cluster Clarifications:

- Relevant components that students need to include in the model are food (carbon-based molecules), oxygen, energy (released and/or absorbed), and new molecules produced through the chemical reactions
- Interactions and relationships that students need to represent and describe in the model include (1) food and oxygen chemically react in cellular respiration; during the reactions, energy is released and the atoms in food are rearranged to form new molecules, (2) matter is conserved during cellular respiration reactions, (3) the matter (atoms) used for growth comes from the products of cellular respiration (thus linking food to the tissues and body structure of the organism), and (4) the energy released during cellular respiration (by rearranging of atoms in food molecules) can be used to support other processes in an organism
- Students are not required to recall formulas for compounds.
- Equations should be shown with words or pictures above them. Large molecules should be drawn as molecular models, not as formulas.
- Items asking students to balance chemical equations, do stoichiometry, explain details of bond energy, address sub-step reactions, etc., are beyond the standard. Focus is on the conceptual understanding that the rearrangement of molecules releases energy and forms new molecules.
- The terms metabolism, anabolism, and catabolism are above grade level.
- Enzymes are not a part of this performance expectation.
- Nutrition scenarios/comparisons may be used for context but should not be the focus of the content to be assessed.

Cluster Stimulus Attributes:

Typical stimulus elements:

- text descriptions
- partial diagrams (to complete or improve), showing the breakdown and building up of molecules and role of energy in this process
- data that could be used to create a model (e.g., data table to be converted to simple flowchart showing movement and changes of matter from intestine into bloodstream)

Possible contexts:

- rearrangement of molecules in digestion (all phases including mouth and intestines)
- loss of energy as heat during metabolic processes; inefficiency of process
- breakdown of the food in the body into smaller pieces, synthesis into new, larger molecules (e.g., for protein in meat, represent food breaking down, represent new molecules being formed)
- junk/healthy food/balanced diets and lack/presence of nutrients
- effect of mechanical breakdown on nutritive value of foods (e.g., blending a steak and eating it; ground beef versus whole steak); lack of difference in nutrition or energy released
- analogies of breakdown and rearrangement of molecules (e.g., toy building blocks)
- use of the energy released from foods in body processes (e.g., fuel for neurons to send signal to heart during exercise)
- carbo-loading by athletes; how is meal put to use? (muscles, brain)
- rearrangement of molecules into larger molecules (e.g., simple models of amino acids, represented as beads on a string)
- effect of nutrition on tree ring growth
- examples of malnourishment in animals/plants

Content and evidence to be included: descriptions or data showing growth, mass, or other metabolic data/process; accessory or partial models describing how molecules are rearranged and energy is released as matter moves through an organism

Types of student responses that need to be supported: creating, completing, and/or improving models of how molecules are rearranged and energy is released as matter moves through an organism; describing and interpreting what the models being developed need to show in order to demonstrate that atoms in food are rearranged through chemical reactions (cellular respiration) to form new molecules and release energy.

Allowable Item Types:

- MC
- TEI

Model Item Descriptions for MS-LS1-7:

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
1	**TEI**	1 or 2 per complexity	Identify the components that need to be included in the model being developed. [Identify the parts that could be used to represent the energy released when food is broken down (by clicking hotspots).] [This model shows how the molecules in food move through an ecosystem. Improve the model by representing where energy is stored within the model (by dragging markers).]	Hot-spot, drag-drop, or drop-down interactions. Must require students to identify or label two or more parts of the model. Correct responses show all identifications or labeling done appropriately. Partial credit would be given for a subset of correct responses.
2	**MC**	2 or 3 per complexity	Identify what needs to be added to the model to complete it (and explain why). [What should be added to the model to show how energy is stored in the new molecules?] [Which of the following explains why oxygen should be added to this model showing the breakdown of food by cells?]	Distractors may include illustrations with incorrect parts (e.g., free energy, oxygen, heat, etc.) or responses based on misconceptions.
3	**MC**	2 or 3 per complexity	Revise the model to better represent how food is rearranged and used. [Which change will allow this model to demonstrate how matter and energy are transformed in respiration?]	Distractors may include misconceptions, changes that do not substantially improve the model, or changes which make the model less useful at demonstrating a given concept.
4	**MC**	1 or 2 per complexity	Identify the (best) model to describe the given phenomenon or process related to rearranging food molecules. [Which model best demonstrates the movement of energy that occurs when food is used by the human body?] [Which model (of digestion) and explanation best fit the data from this experiment?]	Distractors may include models that show an incomplete role of energy, a gain or loss of atoms, or other misconceptions.
5	**MC**	2 or 3 per complexity	Describe/relate the model being developed to the real-life process or phenomenon (e.g., link micro processing of food molecules to macro observations/results and/or emphasis of CCC of conservation of matter). [Which statement explains how the model of digestion being developed could demonstrate the idea that the mass taken in by an organism is used for growth?] [What will the model need to show about what happens to the energy released from food?] [How should the model being developed demonstrate the idea that matter is rearranged, not lost, in the chemical reactions used by the body?]	Distractors may include content misconceptions or erroneous understandings of how a model representation illustrates a phenomenon.

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
6	**TEI**	3	Complete or create a model to describe how food is rearranged during metabolic processes. [Analyze the data in the chart. Then complete the model to show the movement of energy (by dragging parts).]	Drag-drop interaction. Model should require completion of at least three components. Components available to drag should be one or two more than the required components of the model. Correct responses show all labels placed appropriately. Partial credit would be given for a subset of correct responses.

*Response options can make use of Student Misconceptions (examples of scientifically incorrect assumptions) related to this performance expectation; references to misconceptions are listed in the link(s) below:

From http://assessment.aaas.org/topics/ME#/:

- The atoms of the reactants of a chemical reaction are transformed into other atoms.
- New atoms are created during chemical reactions.
- Atoms can be destroyed during a chemical reaction.

From Driver et al (1994). *Making Sense of Secondary Science: Research into Children's Ideas*. London: Routledge:

- Plants get food from the soil.
- Anything taken in by a plant is food.
- Only animals utilize food.

From Keles and Kefeli, http://www.sciencedirect.com/science/article/pii/S1877042810005148:

- Plants use sunlight and/or carbon dioxide as food.
- Photosynthesis is the respiration of plants.

From Oliveira et al, http://advan.physiology.org/content/27/3/97:

- Glucose is the only fuel used by the body (amino acids, lipids, etc., not considered as cellular sources of energy).

From http://modeling.asu.edu/modeling/KindVanessaBarkerchem.pdf:

- If a substance changes in color, mass, or state, a chemical change has taken place.

From http://modeling.asu.edu/modeling/KindVanessaBarkerchem.pdf:

- Many students believe that energy is always released when a chemical reaction occurs.

Biological Unity and Diversity: MS-LS4-1

back to "Item Specifications by Performance Expectation"

MS-LS4-1. Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.

OAS-S Clarification Statement:

Emphasis is on finding patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in the rock layers.

OAS-S Assessment Boundary:

Assessment does not include the names of individual species or geological eras in the fossil record.

Science & Engineering Practice:	Disciplinary Core Idea:	Crosscutting Concept:
Analyzing and Interpreting Data • Analyze and interpret data to determine similarities and differences in findings.	**LS4.A: Evidence of Common Ancestry and Diversity** • The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.	**Patterns** • Graphs, charts, and images can be used to identify patterns in data.

In Lay Terms:

Students should be able to transform and analyze data related to fossils to describe patterns and draw conclusions. As fossils are a record of past life, information about the relative abundance, location, and type of fossils found in different locations can be used to make inferences about life in the past, how life has changed over time, and how living things are related.

Cluster Clarifications:

- The terms "change of life" or "change over time" should be used in place of the term "evolution."
- Do not use symmetrical population graphs of fossil abundance of the type shown here (http://www.edusolution.com/edusolution2/regentsquiz/earthscience/quiz1/ques32.gif) to show changes in number of organisms.
- Do not include radioactive/absolute dating, or the difference between relative and absolute age (focus on relative age only).
- Students are not responsible for memorizing names of eras or fossils, but items may use these terms if defined.
- Students are responsible for understanding the concept of the law of superposition, but do not need to know it by name.
- Although items in a cluster may incorporate the ideas of relative ages or rock layers and fossils embedded in them, the stimulus and majority of items in a cluster should focus on patterns of changes in abundance and extinction of organisms.

Cluster Stimulus Attributes:

Typical stimulus elements:

- diagrams
- tables
- charts
- graphs or text descriptions of fossil evidence

Possible contexts:

- diagrams of outcroppings/formations (or comparisons of outcroppings) showing fossils in each layer and magma intrusions
- maps of locations of fossils
- geological timelines
- partial diagrams or table of rock layers; students place fossils based on relative complexity of structures already shown in diagram
- tables showing progressions of a family of fossils over time to show growth in complexity
- graphs, tables, and diagrams showing changes in diversity or abundance of fossils; graphs showing changes in environmental conditions; graphs showing rates of extinction
- Locations for fossils in Oklahoma include, but are not limited to:
  - Lake Texoma
  - Arbuckle Mountains (Devonian trilobites and brachiopods in limestone formation)
  - Criner Hills
  - Turner Falls
  - Black Mesa dinosaur trackway
  - Freedom, OK

Content and evidence to be included: fossil and geological data related to existence, diversity, extinction, and change of organisms over time

Types of student responses that need to be supported: completing data transformations; identifying patterns and conclusions from data; and making inferences about changes in organisms over time

Allowable Item Types:

- MC
- TEI

Model Item Descriptions for MS-LS4-1:

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
1	**MC**	1	Interpret/read data in tables, graphs, and diagrams (about complexity, diversity, extinction, distribution, relative age). [Based on the data in the graph and table, in what era did crinoids become extinct?]	Distractors may include misinterpretations resulting from incorrect reading of the graph/table/diagram, or other data points found in the stimulus.
2	**MC**	1 or 2 per complexity	Describe simple patterns and trends in tables, graphs, and diagrams (about complexity, diversity, extinction, distribution, relative age). [Based on the data in the graph and table, how did crinoids (diversify) over time?] [Which rock layer shows a dramatic decrease in the number of fossil species that can be observed?]	Distractors may include responses indicating incorrect understanding of trends and patterns.
3	**MC**	1 or 2 per complexity	Transform tabular or text-based data related to fossil appearance/extinction into the form that best emphasizes the patterns within the data (to show change over time or similarities or differences in data sets). [Which graph should be used to most clearly show the difference between these two groups of fossils?] [Which graph is best for showing the changes within this family of fossils?] [Which timeline correctly shows the appearance of the organisms over time?]	Distractors may include graphs that are better suited to other functions, such as scatterplot, bar graph, histogram, or pie graph.
4	**MC**	2 or 3 per complexity	Draw specific conclusions about the existence, diversity, extinction, and changes in life forms from data presented in tables, graphs, and diagrams. [What can be concluded about the relative age of these fossils?] [Based on the information shown in the diagram, during which time period were (name of fossil group) most abundant?] [Based on the evidence presented in the rock layer diagram, which fossils are most likely to be found in layer X?] [The diagram shows rock layers containing members of the echinoid family, relatives of modern sea urchins and sand dollars. What can be concluded about the complexity of this family from the diagram?]	Distractors may include conclusions that result from incorrect interpretations of the trends or patterns found in the data.

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
5	**MC**	2 or 3 per complexity	Describe the data needed to support a given conclusion. [Which data support the conclusion that echinoids diversified into several species before many became extinct?] [Which additional data would be needed to support the idea that the species shown in layer X is the ancestor of the organisms shown in layer W?]	Distractors may include irrelevant data, data that are less useful in supporting the conclusion, or data that actually refute/ reject the conclusion.
6	**MC**	2 or 3 per complexity	Explain *how* specific data support a given conclusion. [How do the data about forams support the conclusion that a die-off of many fossils occurred 100 million years ago?]	Distractors may include explanations that misinterpret the pattern seen in the data.

*Response options can make use of Student Misconceptions (examples of scientifically incorrect assumptions) related to this performance expectation; references to misconceptions are listed in the link(s) below:

From http://www.neisd.net/curriculum/SchImprov/sci/program/misconceptions_inter.htm#geo:

- Geological time/scale may be problematic for students. For example, comprehending the length of time it takes for mountains to erode is difficult for some students.
- Students may define fossils as preserved dead organisms. Many students do not understand that fossils may include evidence such as a portion of remains, impressions, tracks and traces, or that the matter making up an organism may be replaced over time by minerals.
- Students believe that fossils cannot tell us about the environment in which plants or animals lived long ago.

From http://beyondpenguins.ehe.osu.edu/issue/learning-from-the-polar-past/common-misconceptions-about-fossils-and-the-history-of-the-polar-regions:

- Fossils are pieces of dead animals and plants.
- Fossils of tropical plants cannot be found in cold or dry areas.
- Fossils only represent bones and shells of extinct animals. Soft tissue can never be fossilized.

From http://education.msu.edu/irt/PDFs/ResearchSeries/rs165.pdf:

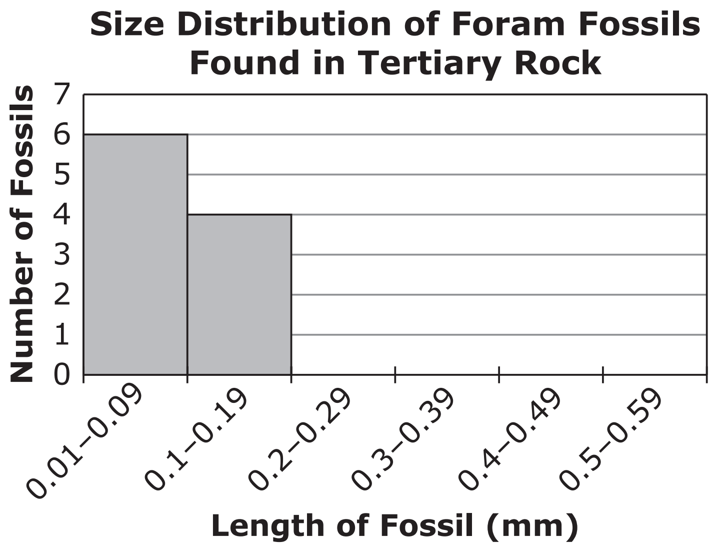
- Organisms develop new traits because they need them to survive.
- A species changes because its members use or fail to use certain body organs or abilities.
- Change occurs to all members of a species.
- The environment directly causes changes to members of a species.
- Traits change progressively in quality as they are passed down to generations of offspring.

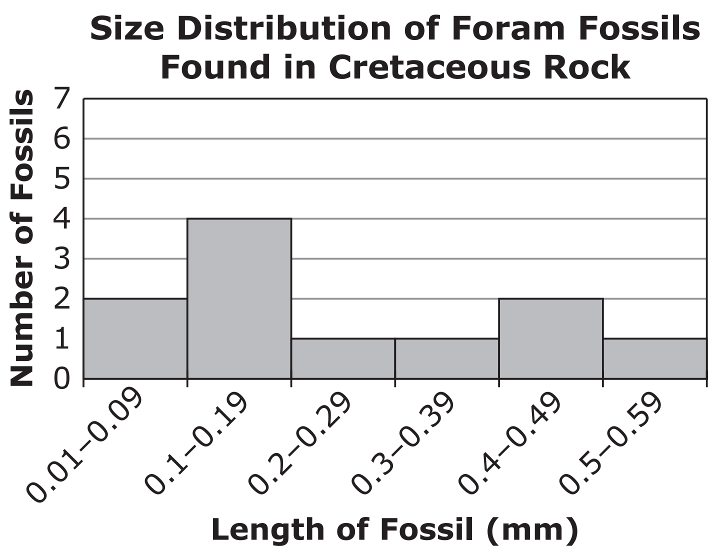
Sample Cluster for MS-LS4-1:

Study the information. Then answer questions 1-3.

To answer questions about Earth's history, students looked at rock samples from different layers of the ocean floor. The rock samples contained fossils of very small ocean organisms called forams.

Some of the rock formed during the Cretaceous time period from 145.5 to 65.5 million years ago, before an event called the K-T extinction. The rest of the rock formed during the Tertiary time period from 65.5 to 35.4 million years ago, after the K-T extinction. In their investigation, the students measured the lengths of the foram fossils in the rock samples. The graphs show the size ranges of the foram fossils in rock samples from each time period.





(Items on the following pages)

1 **Based on the information, how are the foram fossils from the two time periods different?**

A The Cretaceous fossils are found in more locations than the Tertiary fossils.

B The Cretaceous fossils show a greater variety of body forms than the Tertiary fossils.

C The Cretaceous fossils were more successful than Tertiary fossils at surviving the K-T extinction.

D The Cretaceous fossils became more common and the Tertiary fossils disappeared from the fossil record.

Item Type: MC
DOK: 2
Key: B

2 **Which statement is supported by the data in the two graphs?**

A Foram body length increased and forams became extinct between the Cretaceous and Tertiary periods.

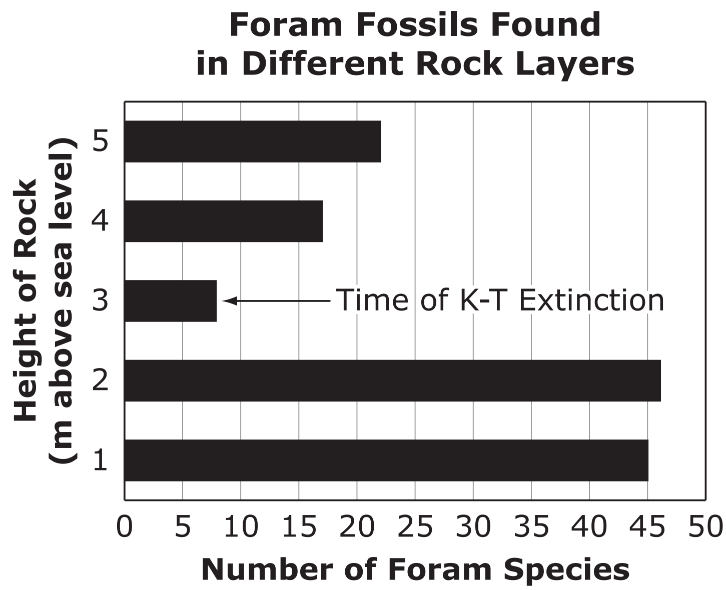
B Foram body length decreased and new foram types appeared between the Cretaceous and Tertiary periods.

C Foram body length decreased and many foram types disappeared between the Cretaceous and Tertiary periods.

D Foram body length did not change and foram populations increased between the Cretaceous and Tertiary periods.

Item Type: MC
DOK: 2
Key: C

3 The students also gathered this data about the number of foram species fossils in rock layers at different heights above sea level from the Cretaceous and Tertiary time periods.



What is the most likely reason for the difference in the number of foram species in the layers from 3 to 5 meters above sea level?

A Individual forams became different species as a result of the K-T extinction.

B An increasing number of foram species were able to survive after the K-T extinction.

C Foram species moved from other parts of the world to this location after the K-T extinction.

D Foram species that were thought to have become extinct during the K-T extinction survived.

Item Type: MC
DOK: 3
Key: B

Biological Unity and Diversity: MS-LS4-2

back to "Item Specifications by Performance Expectation"

MS-LS4-2. Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer ancestral relationships.

OAS-S Clarification Statement:

Emphasis is on explanations of the ancestral relationships among organisms in terms of similarity or differences of the gross appearance of anatomical structures.

OAS-S Assessment Boundary:

(none)

Science & Engineering Practice:	Disciplinary Core Idea:	Crosscutting Concept:
Constructing Explanations and Designing Solutions • Apply scientific ideas to construct an explanation for real-world phenomena, examples, or events.	**LS4.A: Evidence of Common Ancestry and Diversity** • Anatomical similarities and differences between various organisms, living today and found in fossil records, enable inferences of degree of relatedness among organisms.	**Patterns** • Patterns can be used to identify cause-and-effect relationships.

In Lay Terms:

Students should be able to incorporate scientific ideas to analyze anatomical structures and use this data to explain relatedness and ancestry of organisms.

Cluster Clarifications:

- Use the term "reject" in place of "refute."
- Avoid analysis of primate and hominid data.
- At this grade level, anatomy should be the focus of comparisons, not DNA or protein similarities.
- Avoid the term evolution. Use "changes in species" or "change over time" or "adaptation."
- Avoid high school terminology such as adaptive radiation, homologous and analogous, fitness.
- Do not use cladograms or phylogenetic trees.

Cluster Stimulus Attributes:

Typical stimulus elements:

- diagrams including anatomical similarities
- data tables and graphs showing fossil abundance and distribution
- text-based descriptions of anatomy, fossil abundance, and distribution

Possible contexts:

- changes (or lack of changes) in fossil anatomy over time (e.g., changes in ammonoid suture lines [as found in samples from Oklahoma's Lake Texoma]; John Day [Oregon] horse fossils; sharks)
- comparison of fossils found in deep and shallow water to show changes in fossils (e.g., why does fossil sequence show development of legs?)
- comparisons of diversity among plant fossils over time, or comparisons of diversity of plant fossils and existing plants (e.g., fossil of gingko and environment where one would find it today—what can be inferred about past environment?)
- modern anatomical comparisons (e.g., similar forearm structure in bird, bat, frog)

Content and evidence to be included: data related to anatomical characteristics of different organisms, as well as their locations, abundance, time period, etc.

Types of student responses that need to be supported: using evidence and reasoning to explain patterns in relatedness and ancestry of organisms, and/or the relationship between species change and environmental change

Allowable Item Types:

- MC
- TEI

Model Item Descriptions for MS-LS4-2:

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
1	**MC**	2 or 3 per complexity	Analyze data to infer the relatedness among modern organisms. [Based on the characteristics shown in the table, which two organisms are most distantly related?] [What can be concluded from the students' analysis of the skeletal structures in a snake and lizard?] [Which of the following inferences can be made about relatedness of organisms using the data in the table?]	Distractors may include inferences that are weakly supported by the evidence (e.g., similar size, similar location, similar color) or are unrelated or contradictory to the evidence.
2	**MC**	2 or 3 per complexity	Identify which statement/clarification will best improve the explanation of relatedness or ancestry of species. [A student inferred that whales and cows are closely related because they have similar body structures. Which statement improves upon the student's explanation?]	Distractors may include information/data/trivial statements that do not provide an improved explanation.
3	**MC**	2 or 3 per complexity	Infer the relatedness among modern and fossil organisms. [The diagram shows the structures found in modern and extinct reptiles. What can be inferred from the differences in these structures?] [Based on the information shown, which two species are most closely related to (extinct organism)?] [Based on the diagram, what is the most recent ancestor of species (X) and (Y)?]	Distractors may include inferences that are weakly supported by the evidence (e.g., similar size, similar location, similar color) or are unrelated or contradictory to the evidence.
4	**MC**	2 or 3 per complexity	Relate changes in species to changes in environmental conditions. [Based on the description of the environmental changes, which statement explains the characteristics of the plant labeled X compared to the plant labeled Y?]	Distractors may include characteristics or explanations based on misconceptions or unrelated changes.
5	**TEI**	2 or 3 per complexity	Relate changes in species to changes in environmental conditions. [The table shows changes to the environment in eastern Oregon over past years. Based on the data, select the features that would be expected for a horse living 26 million years ago.]	TEI interaction is hot-spot. Correct responses show all correct identifications. Partial credit would be given for a subset of correct responses.
6	**MC**	2 or 3 per complexity	Use multiple sources of evidence to explain the causes of specific adaptions. [Based on the data presented, explain what accounts for the difference in beak shape for Galapagos finches.]	Distractors may include statements explaining reasoning for other outcomes, or erroneous explanations.

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
7	**MC**	2	Identify the evidence that supports the given explanation for how two species (modern, or modern and fossil) are related. [The diagram shows a drawing and information about an extinct crinoid and a modern-day sea fan. Which piece of evidence best supports the inference that these two organisms are related?] [Which evidence best supports the inference that organisms X and Y are more closely related than organisms Y and Z?]	Distractors may include data that does not provide sufficient/valid evidence or which contradicts the explanation.
8	**MC**	2	Describe the reasoning that connects the evidence of body structures to a conclusion about relatedness or ancestry of species. [Which statement describes the reasoning that led a student to conclude that butterflies and skippers are more closely related than moths and butterflies?]	Distractors may include statements including invalid/unsupported reasoning or valid/supported reasoning for alternate hypotheses or phenomena.
9	**MC**	2	Describe the reasoning that connects changes over time in anatomical features to lines of evolutionary descent. [Which statement describes the reasoning that led the group to conclude that Primelephas is the most recent extinct ancestor of African elephants?]	Distractors may include statements including invalid/unsupported reasoning or valid/supported reasoning for alternate hypotheses or phenomena.

*Response options can make use of Student Misconceptions (examples of scientifically incorrect assumptions) related to this performance expectation; references to misconceptions are listed in the link(s) below:

From http://www.neisd.net/curriculum/SchImprov/sci/program/misconceptions_inter.htm#geo:

- Earth and space science have a unique aspect of scale that may be problematic for students. For example, comprehending the length of time it takes for mountains to erode is difficult for some students.
- Fossils are the remains of dead organisms. Many students do not understand that fossils also include other types of evidence such as tracks and traces.
- Fossils cannot tell us about the environment in which plants or animals lived long ago.

From http://assessment.aaas.org:

- Species that are similar can share a common ancestor, but species that have no apparent, obvious, or superficial similarities cannot share a common ancestor.
- Members of different species do not share a common ancestor.
- Species that have no apparent, obvious, or superficial similarities have no similarities at all.
- Plants and animals cannot share a common ancestor.

Earth's Place in the Universe: MS-ESS1-4

back to "Item Specifications by Performance Expectation"

MS-ESS1-4. Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's geologic history.

OAS-S Clarification Statement:

Emphasis is on analyses of rock formations and fossils they contain to establish relative ages of major events in Earth's history. Major events could include the formation of mountain chains and ocean basins, adaptation and extinction of particular living organisms, volcanic eruptions, periods of massive glaciation, and the development of watersheds and rivers through glaciation and water erosion. The events in Earth's history that happened in the past continue today. Scientific explanations can include models.

OAS-S Assessment Boundary:

Assessment does not include recalling the names of specific periods or epochs and events within them.

Science & Engineering Practice:	Disciplinary Core Idea:	Crosscutting Concept:
Constructing Explanations and Designing Solutions • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**ESS1.C: The History of Planet Earth** • The geologic time scale interpreted from rock strata provides a way to organize Earth's history. • Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.	**Scale, Proportion, and Quantity** • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

In Lay Terms:

Students should be able to use data and earth science principles to explain, support, or critique explanations related to determining the relative date, sequence, or scale of events in Earth's history.

Cluster Clarifications:

- Use the term "reject" in place of "refute."
- While students are not responsible for knowing names of periods/epochs, these can be used to identify parts of diagrams, etc.
- This performance expectation focuses less on fossils than other performance expectations, and more on the sequencing of landform events that have occurred.
- For items asking about the sequence of formation of specific geologic features or manmade features such as road cuts, avoid Oklahoma examples, as students may have memorized information about local features, leading to bias. Use out of state features instead. Local features may be used in items where subgroups of students will not have benefited from previous exposure or memorization.
- Students are not responsible for the names of specific landforms (e.g., moraine, drumlin, mesa, butte, lava dome, alluvial fan, sand bar, etc.).
- Students are not responsible for the names of specific catastrophic events (e.g., Chixculub impact, K-T event, etc.).
- Students are responsible for the concepts of uniformitarianism, superposition, and intrusions, but are not responsible for recognizing or defining these terms.
- There must be items in the cluster that ask about the principles and reasoning for how the relative ages or sequences of events were determined. This performance expectation is about how the timeline was determined, not about the processes that formed rock strata, landforms, etc.

Cluster Stimulus Attributes:

Typical stimulus elements:

- diagrams of rock strata and geological formations
- timelines
- data tables
- graphs

Possible contexts:

- rock layers/profiles (including but not limited to Grand Canyon; fossils at top of Himalayas formed during collision of India/Asia; Haymond Bed, Texas; Williston Basin, Montana)
- formation of geologic features (including but not limited to Boring Lava Domes; Mammoth Cave, KY; Niagara Falls; formation of Great Lakes by continental glaciers; Great Salt Lake)
- evidence of past catastrophic events (including, but not limited to, worldwide data supporting Chixculub hypothesis, evidence of Bretz/Missoula flood, past eruptions of Cascade Volcanoes – e.g., Mt. Mazama, Osceola, and Electron Mudflows)
- descriptions of classroom models/experiments

Content and evidence to be included: observations and data about rock type, fossil type/distribution, and/or geological changes

Types of student responses that need to be supported: providing explanations (i.e., timelines, sequences) with evidence and reasoning describing how time scales and relative order of events/ages were determined

Allowable Item Types:

- MC
- TEI

Model Item Descriptions for MS-ESS1-4:

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
1	**MC**	2	Determine/infer relative ages or sequences of events based on rock strata data, incorporating the idea of time scales. [What sequence of events occurred such that layer Y is older than layer X?]	Distractors may include erroneous ages and sequences, based on misconceptions about relative dating.
2	**MC**	2	Explain how to use data, models, and other evidence to date and sequence geologic events (i.e., provide the reasoning). [How does this model show how layer W can be younger than layer X?]	Distractors may include representations that include only a subset of data or which misinterpret data.
3	**MC**	2 or 3 per complexity	Describe the evidence that supports a given timeline or sequence of a set of geologic events or formation of a particular geologic feature. [Which data support the sequence of events determined for the formation of the Grand Canyon?]	Distractors may include information which is irrelevant to the sequencing of events.
4	**MC**	2 or 3 per complexity	Describe the evidence used to compare ages of different rock strata. [Which evidence supports the idea that layer X and layer Z are the same age?]	Distractors may include evidence that is irrelevant or which is present in only one rock strata.
5	**TEI**	2 or 3 per complexity	Use rock strata data to construct a timeline of geologic events. [Using reasoning from the evidence of the rock strata, order the rock formation layers from youngest to oldest.] [Using reasoning from the evidence of the rock strata, place each event in the correct place on the timeline (by dragging event labels).]	Drag-drop interaction. Draggable descriptions may be for several possible events (violent volcanic eruption, deposition of sediment, formation of coral reef, faulting, water erosion, wind erosion, submersion under ocean) and goal boxes ask for a subset of events in the sequence on the timeline. Correct responses show fully correct sequence/order/placement. Partial credit would be given for a subset of correctly ordered responses.
6	**MC**	2 or 3 per complexity	Determine whether the rock strata data support or reject a particular geologic time scale explanation, (and provide the reasoning/explain why).	Distractors may include reasoning or explanations that are erroneous or which cite data that are irrelevant to the events of the time scale.
7	**MC**	2 or 3 per complexity	Describe how (and/or why) the explanation of geologic history at a point of significant geologic activity (volcano, crater, river delta, etc.) may be improved based on rock strata data from an adjacent or corresponding location.	Key for questions asking "why" should focus on how the data, along with geology principles, are used to determine relative ages of events.

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
8	**MC**	2	Identify which model or explanation of the time scale of events is most accurate.	Distractors may include models or explanations which are less accurate, or which ignore key data.
9	**MC**	2 or 3 per complexity	Describe additional evidence that would support the proposed ages or sequences of events (and explain why that information would be quality evidence).	Distractors may include evidence that is repetitive, irrelevant, or less useful than the key.

*Response options can make use of Student Misconceptions (examples of scientifically incorrect assumptions) related to this performance expectation; references to misconceptions are listed in the link(s) below:

From http://www.neisd.net/curriculum/SchImprov/sci/program/misconceptions_inter.htm#geo:

- Earth and space science have a unique aspect of scale that may be problematic for students. For example, comprehending the length of time it takes for mountains to erode is difficult for some students.

From MiTEP, http://hub.mspnet.org/media/data/MiTEP_List_of_Common_Geoscience_Misconceptions.pdf?media_000000007297.pdf:

- There is one geologic column for the whole earth.
- All rocks and planets were formed at the same time.
- All rocks are more or less the same.
- Geologic time can be understood in terms of hundreds of years.
- The earth is younger than 4.6 billion years.
- Rock layers are always flat. If we don't see mountains in an area, they never existed there.

From Annenberg, http://www.learner.org/series/modules/express/pages/scimod_32.html:

- Seashells are found on mountains because the sea level was higher in the past.
- Sedimentary rocks form when sediments stick together at the bottom of a river; heat may be involved.
- All rock has existed since the formation of the Earth.
- Rocks form where they are found.

From http://www.aea10.k12.ia.us/vastscience/toolkits/earthmaterials/studentpreconceptions.html:

- All rocks come from volcanoes.
- All rocks come from the moon.
- Rocks grow from dirt.

From http://www.academia.edu/2063292/Misconceptions_in_the_National_Curriculum_Identification_and_formation_of_rock_types_in_Key_Stage_3_and_4:

- Students use irrelevant criteria, such as shape, size, color, and density to identify rocks.

From http://www.nsta.org/publications/news/story.aspx?id=52474:

- All changes to Earth's surface occur suddenly and rapidly.
- All events that affect Earth are gradual or slow.
- All Earth processes operate at the same rate (on the same time-scale).
- All changes to Earth occur so slowly that they cannot be detected during a human lifetime.
- Only erosion causes changes to Earth's surface.

Earth's Systems: MS-ESS2-1

back to "Item Specifications by Performance Expectation"

MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.

OAS-S Clarification Statement:

Emphasis is on the processes of melting, crystallization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth's materials.

OAS-S Assessment Boundary:

Assessment does not include the identification and naming of minerals.

Science & Engineering Practice:	Disciplinary Core Idea:	Crosscutting Concept:
Developing and Using Models • Develop a model to describe phenomena.	**ESS2.A: Earth's Materials and Systems** • All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.	**Stability and Change** • Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale.

In Lay Terms:

Students should be able to identify, complete, and describe components and relationships for a model (i.e., develop a model) to describe the processes that form/transform minerals and rocks and the energy that drives this cycle (energy from the Earth's interior and solar energy).

Cluster Clarifications:

- Both the cycling of matter and the energy that drives the cycling are important parts of the model to develop.
- Relevant components that students need to include in the model are Earth materials (at surface or interior, those before and after changes); energy (from the Sun or Earth's interior); earth processes; and the scale for the system.
- Interactions and relationships that students need to represent and describe in the model include (1) processes (e.g., melting, sedimentation, crystallization) driving matter cycling through physical and chemical changes, and (2) movement of energy from Earth's interior and/or input of energy from the Sun causing cycling of matter via Earth processes (e.g., Earth's internal heat energy drives processes such as melting, crystallization, and deformation; the Sun's energy drives the movement of wind and water to cause weathering, erosion, and sedimentation; and given the right setting, any rock can be changed into a new type of rock by these processes and energy input).
- Contexts may include intrusive and extrusive rock, but these terms should not be used.
- Changes focusing on water are not a part of this performance expectation and align to MS-ESS2-2 instead.
- Items should incorporate the idea that the amount of matter with the rock cycle remains stable despite changes to its form, as a cycle cannot occur without conservation of matter.

Cluster Stimulus Attributes:

Typical stimulus elements:

- text descriptions of observations, sequences, or phenomena
- partial diagrams (to complete or improve), showing cycling or stages in rock cycle, or processes within these stages

Possible contexts:

- changes in mineral structure, crystallization, recrystallization of metamorphic rock
- comparisons of phenomena, to help incorporate/address changes in scale (CCC), e.g., mud slide versus deposition of geological layers; volcanic eruptions versus Hawaiian islands over large time frame
- various models including, but not limited to:
  - diagrams of the rock cycle
  - use of household materials to describe rock cycle, such as clay, crayons, soft candies
  - use of play clay and rice to model formation of metamorphic rock and alignment of crystals
  - use of sand and syringe and cementing agents to model formation of sedimentary rock
  - use of egg white and beaker of hot water to model formation of metamorphic rock via igneous intrusions
  - use of salol or other materials that crystalize quickly to model changes in crystal size due to rate of cooling
  - use of inclined tray, sugar, and water dropper to model weathering

Content and evidence to be included: descriptions and/or data that can be used to make inferences about these processes and build descriptive models

Types of student responses that need to be supported: creating, completing, and/or improving models of the cycling of Earth's materials; describing and interpreting what components and relationships the models being developed need to show/account for in order to demonstrate the processes and energy inputs in the cycling of Earth's materials

Allowable Item Types:

- MC
- TEI

Model Item Descriptions for MS-ESS2-1:

#	Item Type	DOK	Model Stem (Items ask students to…)	Response Characteristics*
1	**MC**	1 or 2 per complexity	Describe pathways that should be in the model, and/or how to represent them. [Which pathway should be included in the model to show how sedimentary rock can be produced?]	Distractors may include incorrect or irrelevant pathways.
2	**TEI**	2	Show/create pathways that should be in the model. [In the model, create one possible pathway for a rock to turn into a metamorphic rock (by clicking hotspots).]	Hot-spot interaction. Model should include multiple possible pathways, as well as the opportunity to trace incorrect pathways. Correct responses show all expected/correct pathways. Partial credit could be given for a subset of correct pathways or sequences.
3	**MC**	1 or 2 per complexity	Describe what the model needs to show (e.g., basic purpose, components) about the cycling of Earth's materials or energy flow. [Which materials should be used to represent the different rock types in the model, and why?]	Distractors may contain misconceptions or misinterpretations of the needed model and its components.
4	**MC**	1 or 2 per complexity	Describe how to develop/complete the model to show the relevant processes or phenomena related to cycling of Earth materials or energy flow. [Which household material could be added to this model to describe how sedimentation occurs?]	Distractors may include materials or components that are not appropriate to the model being described.
5	**TEI**	2	Complete the model to show the relevant processes or phenomena related to cycling of Earth materials or energy flow. [Complete the model of the rock cycle (by dragging and dropping the words and symbols).]	TEI interaction is drag-drop. Correct responses show all objects/words/labels placed correctly. Partial credit would be given for a subset of correct responses.
6	**MC**	2	Describe/relate the model being developed to the real-life process or phenomenon (matter and energy flow in Earth material cycling). [How can the model be developed to show that the Sun's energy is related to weathering?] [Which processes should the model show are driven by the heat from Earth's interior?] [How can the model of the rock cycle be built to demonstrate conservation of mass?]	Key should focus on connecting the model and the real-life materials, energy, and processes the model represents. Distractors may include incorrect identification of processes or drivers of processes, or incomplete or incorrect explanations of the concepts and connections underlying the model.

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
7	**MC**	2	Identify relationships between inputs and outputs that need to be shown in the model being developed. [Which statement describes the relationship that should be shown between energy and cycling of matter in the rock cycle?]	Distractors may contain statements describing possible misconceptions related to inputs, outputs, and processes described in the model, or incorrect relationships.
8	**MC**	3	Revise the model to better represent cycling of Earth materials or energy flow. [How should this model be corrected to show how sedimentary rocks are formed?] [Which change will allow this model to demonstrate the idea that the amount of matter within the rock cycle remains the same over time?]	Distractors may include descriptions of changes that are irrelevant to the concept described or which will represent the concept incompletely.
9	**MC**	2 or 3 per complexity	Select the model that best fits a set of observations or data. [Which model (of crystal formation) and explanation best fit the data from this experiment?] [Which model best represents the process of weathering?]	Distractors may include models and explanations that do not consider changes described in data or which misinterpret these changes.
10	**MC**	2 or 3 per complexity	Describe the appropriate scale(s) for the model being developed. [Which statement describes how the scale of processes should differ in this model?] [What is one short-term change that could be included in this model?]	Distractors may include statements indicating a misunderstanding of the scales described in the model, or misconceptions related to scale of matter.
11	**MC**	2	Identify evidence that supports the model being developed. [Which evidence supports the model the students are creating?]	Distractors may include irrelevant evidence or evidence that refutes the model.

*Response options can make use of Student Misconceptions (examples of scientifically incorrect assumptions) related to this performance expectation; references to misconceptions are listed in the link(s) below:

From http://serc.carleton.edu/NAGTWorkshops/intro/misconception_list.html:

- Magma comes from a molten layer beneath Earth's crust.
- Most magma forms as rock melts, due to an increase in temperatures.

From http://www.lpi.usra.edu/education/step2012/participant/rockCycle.shtml:

- Layered rock is always sedimentary.
- One type of rock can only change to another type (e.g., igneous can only change to sedimentary or metamorphic rather than melting again and changing to another type of igneous rock.).
- Metamorphic rocks are a "little melted."
- Metamorphic rocks require both heat and pressure to form.
- Any amount of pressure or heat will cause a rock to metamorphose (in reality, some pressure may just make a sedimentary rock, while too much heat will melt a rock, resulting in an igneous process).

Earth's Systems: MS-ESS2-2

back to "Item Specifications by Performance Expectation"

MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.

OAS-S Clarification Statement:

Emphasis is on how processes change Earth's surface at time and spatial scales that can be large (such as slow plate motions or the uplift of a large mountain range) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes usually behave gradually but are punctuated by catastrophic events (such as earthquakes, volcanoes, and meteor impacts). Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate.

OAS-S Assessment Boundary:

(none)

Science & Engineering Practice:	Disciplinary Core Idea:	Crosscutting Concept:
Constructing Explanations and Designing Solutions • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**ESS2.A: Earth's Materials and Systems** • The planet's systems interact over scales that range from microscopic to global in size. These interactions have shaped Earth's history and will determine its future. **ESS2.C: The Roles of Water in Earth's Surface Processes** • Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.	**Scale Proportion and Quantity** • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

In Lay Terms:

Students should be able to explain the role of geological processes (plate motions, catastrophic events, weathering, erosion, and deposition, including water effects) in causing changes to Earth's surface on both large and small spatial and time scales.

Cluster Clarifications:

- Use the term "reject" in place of "refute."
- Avoid specific terms related to topography, such as oxbow, meanders, floodplain, mesa, cut bank, sandbars, karst, etc., unless critical to the item and defined within the item.
- Students are responsible for the concept of uniformitarianism, but are not responsible for recognizing or defining this term.

Cluster Stimulus Attributes:

Typical stimulus elements:

- graphs
- data tables
- diagrams
- text descriptions

Possible contexts:

- real-world models or data showing change over time in production of geological features or phenomena at different time scales
  - Oklahoma geological features include, but are not limited to, karst (limestone cave-rich) topography; black mesa volcanoes; great plains; uplifted and folded mountains such as the Arbuckle and Sans Bois Mountains; erosion and weathering as cause of flat-topped mountains in Oklahoma; meanders and oxbows on Washita River and Arkansas River near Muskogee; sand dunes of Little Sahara State Park
  - earth processes common to Oklahoma include, but are not limited to, tornadoes, wind shears and thunderstorms, flooding and erosion/sedimentation caused by floods, wind erosion (historical dust bowl), drought, meteor impacts
- catastrophic/sudden changes or gradual/long term changes—volcanic eruption/island formation versus formation of land via silting/deposition at river delta
- uniformitarianism—mountain (e.g., Appalachian) and outline of its former height overlaid, students describe the changes that occurred, or draw model of the way that mountain has declined over the years; distinguish between weathering and erosion
- cause-and-effect relationships—relationship between rainfall/flooding and sedimentation

Content and evidence to be included: diagrams/drawings, graphical representations, and texts describing various changes to Earth's surface

Types of student responses that need to be supported: explaining geoscience processes and how changes in Earth's surface are occurring, with evidence and reasoning to support or revise explanations

Allowable Item Types:

- MC
- TEI

Model Item Descriptions for MS-ESS2-2:

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
1	**MC**	1 or 2 per complexity	Identify the timescale associated with a given geological process or phenomenon. [What is the smallest time span in which an observer could see changes in Earth's surface resulting from the movement of the (divergent) plate boundary shown in the diagram?] [A diagram of the formation of a mountain is shown. Which of the following describes the time scale needed for this process to occur?]	Distractors may include time spans that are too short or long to result in the observed phenomenon.
2	**MC**	1 or 2 per complexity	Identify/describe the evidence needed to support/reject the explanation of the process(es) underlying a geological phenomenon. [Which evidence should be collected to support the explanation of how small scale movement of Earth's tectonic plates results in large scale changes in Earth's surface features?] [Which evidence supports the explanation of how both small and large scale changes result in earthquakes?]	Distractors may include evidence that is irrelevant or which does not provide the intended support or rejection of the explanation.
3	**MC**	2	Describe *how* a given data set supports an explanation about geological processes. [How does the information comparing the amounts of sediment in different rivers to the amounts of recent rainfall support the explanation of how erosion from the river has changed over time?] [How does the change in the rainfall support the explanation of how flooding causes erosion?]	Distractors may include descriptions that incorrectly explain how the given data supports or rejects the explanation, or which show a misunderstanding of the premises of the explanation.
4	**MC**	2 or 3 per complexity	Make explanations related to formation of geologic features to choose the one that is best supported by the data in a graph, table, or diagram. [Which explanation about the formation of oxbow lakes is best supported by the data in the photographs?]	Distractors may include explanations that are only partially supported by the data, or which are partially rejected by the data.
5	**MC**	2 or 3 per complexity	Select the reasoning that best supports the explanation for how the geologic process changed earth's surface/features. [Which reasoning best supports the explanation for the effects of rainstorms on Earth's surface features?]	Distractors may include reasoning that incompletely supports the explanation or which could be used to reject the explanation.

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
6	**MC**	2 or 3 per complexity	Identify the evidence that supports a given explanation. [Which evidence best supports this model of erosion?] [Which evidence supports this model (that erosion occurs at different scales)?]	Distractors may include irrelevant evidence or evidence that contradicts the explanation.
7	**MC**	2 or 3 per complexity	Compare how well various explanations incorporate given data. [Which explanation of erosion best fits the data provided?]	Distractors may include explanations that do not adequately incorporate the data.
8	**MC**	2 or 3 per complexity	Select the model that best incorporates a given data set. [Which model of deposition best reflects the data shown in the table?]	Distractors may include models that incompletely incorporate data or which misrepresent data.
9	**MC**	2 or 3 per complexity	Describe the evidence needed to revise or improve an explanation. [Which evidence should the student collect to support her new explanation that processes occurring at different time frames resulted in the formation of the flat-topped mountain shown in the illustration?]	Distractors may include evidence that is irrelevant, repetitive, or which otherwise will not improve the quality of the explanation given.

*Response options can make use of Student Misconceptions (examples of scientifically incorrect assumptions) related to this performance expectation; references to misconceptions are listed in the link(s) below:

From http://newyorkscienceteacher.com/sci/pages/miscon/geol.php:

- Soil must have always been in its present form. Mountains are created rapidly.

From http://serc.carleton.edu/NAGTWorkshops/intro/misconception_list.html:

- Earthquakes are rare events (media coverage of earthquakes is limited and biased to U.S. area or high death tolls).
- Volcanic eruptions are rare events (media coverage is biased by location and death tolls).
- Floods are atypical, almost unnatural events rather than normal river behavior.
- Although rivers can cut down over time, they do not cut to the sides.

From MiTEP, http://hub.mspnet.org/media/data/MiTEP_List_of_Common_Geoscience_Misconceptions.pdf?media_000000007297.pdf:

- Geologic time can be described in terms of hundreds of years ago.
- It is easy to understand the amount of geologic time that has passed for changes on Earth's surface to occur.
- Earth is younger than 4.6 billion years old.
- People's "traditional" sense of time has always existed.
- Catastrophic changes on Earth's surface, like volcanic eruptions and earthquakes, only affect the lithosphere.
- The atmosphere, hydrosphere, lithosphere, and biosphere do not cause changes in one another; these systems operate independently on Earth.
- Earth has always been pretty much the way it is now.
- Rivers do not carve valleys, but only passively flow down them.

From Earth Science Misconceptions, Philips, February 199.
http://k12s.phast.umass.edu/~nasa/misconceptions.html:

- Floods along rivers happen only after snow melts in the spring.

Earth's Systems: MS-ESS2-3

back to "Item Specifications by Performance Expectation"

MS-ESS2-3. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.

OAS-S Clarification Statement:

Examples of data include similarities of rock and fossil types on different continents, the shapes of the continents (including continental shelves), and the locations of ocean structures (such as ridges, fracture zones, and trenches).

OAS-S Assessment Boundary:

Paleomagnetic anomalies in oceanic and continental crust are not assessed.

Science & Engineering Practice:	Disciplinary Core Idea:	Crosscutting Concept:
Analyzing and Interpreting Data • Analyze and interpret data to provide evidence for phenomena.	**ESS1.C: The History of Planet Earth** • Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches. *(secondary to MS-ESS2-3)* **ESS2.B: Plate Tectonics and Large-Scale System Interactions** • Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart.	**Patterns** • Patterns in rates of change and other numerical relationships can provide information about natural systems.

In Lay Terms:

Students should be able to transform and interpret data related to plate movement to describe patterns and draw conclusions. Information about the relative location and age of rocks and fossils, shapes of the continents, and structures on the ocean floor can be used to make inferences about the past location of continents/plates and their rate of movement.

Cluster Clarifications:

- This performance expectation is limited to movement of plates and their relationship to sea floor structures, and distribution of rock strata and associated fossils, as evidence of plate movement.
- Subduction as part of this process (loss of sea floor at trenches) is within scope, but subduction as cause of volcanoes, and collision of continental plates to form mountains is beyond scope.
- Likewise, hotspots as support for plate tectonics is within scope, but the cause of the ring of fire is beyond scope.
- Magnetic sea floor evidence (geomagnetic reversals) is beyond grade level.

Cluster Stimulus Attributes:

Typical stimulus elements:
- diagrams
- tables
- charts
- maps
- graphs
- text descriptions of fossil, geological, and geographic evidence

Possible contexts:
- evidence supporting existence of formation of Pangea
- fossil and glacier evidence supporting past locations of plates
- data tables showing movement of landmarks over time
- fossil evidence showing past linkage of Africa, South America, and Australia
- relative age of crust at different distances from mid-Atlantic ridge
- relative ages of oceanic and continental crust
- oceanic hot spots (e.g., Hawaii)
- analysis of shapes of continents and/or continental shelves

Content and evidence to be included: fossil, geographic, and geological data related to plate movement

Types of student responses that need to be supported: transforming data; describing patterns and conclusions from data; and making inferences about plate movement over time

Allowable Item Types:
- MC
- TEI

Model Item Descriptions for MS-ESS2-3:

#	Item Type	DOK	Model Stem (Items ask students to…)	Response Characteristics*
1	**MC**	1 or 2 per complexity and item type	Identify the order of the movement of tectonic plates/plate motion over time. [Based on the data/evidence, which diagram that shows the plate motions over time?]	Distractors may include random ordering or ordering from highest to lowest quantity or rate or vice versa.
2	**TEI**	2	Order of the movement of tectonic plates/ plate motion over time. [Based on the data/evidence, order the diagrams to show plate motions over time (by dragging diagrams).]	TEI interaction is drag-drop. Correct responses show all diagrams/ phases in correct order. Partial credit would be given for a subset of correctly ordered diagrams/ phases.
3	**MC**	2 or 3 per complexity	Describe the direction or extent of plate movement from provided data. [Based on the information in the data table and diagram, which diagram shows the direction of movement for these plates?] [Based on the data, which statement describes the motion of the oceanic plates on each side of the ridge?]	Distractors may include plate movements inconsistent with the data shown in the table and/or diagram.
4	**TEI**	2 or 3 per complexity	Show the direction or extent of plate movement from provided data. [Using the information (formation of trenches and data on distance between locations), show the direction of movement for each of the plates shown (by dragging the arrows).]	TEI interaction is drag-drop. Matching could also be used depending on number of plates and complexity of graphics. Correct responses show the correct directions for each required plate motion. Partial credit would be given for a subset of correct responses.
5	**MC**	2 or 3 per complexity	Identify/infer past plate locations from evidence provided. [Based on the evidence provided (about Hawaiian Islands), how has the location of the tectonic plate changed over time?]	Distractors may include locations that would result from differing plate movements.
6	**TEI**	2 or 3 per complexity	Identify/infer past plate locations from evidence provided. [Based on the evidence provided, select all the plates that formed the ancient supercontinent of Pangea in the past (by clicking hotspots).]	TEI interaction is hot-spot. Correct responses show all hotspots that are associated with or create the indicated locations, motions, or features. Partial credit would be given for a subset of correct responses.

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
7	**MC**	2 or 3 per complexity	Explain *how* the specific data/evidence support the conclusion about plate motion or provide evidence of plate motions. [How does the presence of a volcanic ridge that runs down the center of the Atlantic Ocean seafloor support the idea that the plates making up this region are spreading apart?] [How does the difference in age between continental and oceanic rock support the idea that rock is continually generated and destroyed?] [Based on the data shown in the diagram, how does the shape of the African continent over time provide evidence that the earth's plates have moved?]	Distractors may include incorrect analysis or interpretation of data in conjunction with erroneous or irrelevant conclusions from evidence given.
8	**MC**	1	Describe/read data in tables, graphs, maps and diagrams (about fossil and rock similarity among continents, shapes of continents, and location of ocean structures) to assess the degree/quality of support they provide for an explanation/ conclusion about plate movement. [Based on the data shown in the diagram, which continent has fossils and rocks similar to those seen in South America?]	Distractors may include misinterpretations resulting from incorrect reading of graphs, tables, and diagrams, or other data points found in the stimulus.
9	**MC**	1 or 2 per complexity	Describe simple patterns and trends in tables, graphs, and diagrams (about fossil and rock similarity among continents, shapes of continents, and location of ocean structures). [Which two continents have the greatest similarity among fossils and rock layers?]	Distractors may include responses indicating incorrect understanding of trends and patterns.
10	**MC**	1 or 2 per complexity	Transform tabular or text-based data related to evidence of plate movement into the graphic form that best emphasizes the patterns within the data (to show change over time or similarities or differences in data sets). [Which of the following graphs should be used to most clearly show the abundance of fossils on each continent?] [Which graph best shows the rate of spreading of the Atlantic sea floor?]	Distractors may include graphs that are better suited to other functions, such as scatterplot, bar graph, histogram, or pie graph.

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
11	**MC**	2 or 3 per complexity	Draw specific conclusions about the movement of plates, based on the given data. [Based on the data shown in the diagram and table, what does the presence of marsupial fossils suggest about South America and Australia?] [What can be inferred from the data shown in the table (showing change in diameter of the Atlantic between two locations over time)?] [What can be inferred about the past location of this continent from the data provided (tropical fossils, glacial evidence)?]	Distractors may include inferences that result from incorrect interpretations of the trends or patterns found in the data, or possible misconceptions related to plate movement (e.g., divergent movement increases size of Earth.)

*Response options can make use of Student Misconceptions (examples of scientifically incorrect assumptions) related to this performance expectation; references to misconceptions are listed in the link(s) below:

From http://serc.carleton.edu/NAGTWorkshops/intro/misconception_list.html:

- Crust and lithosphere (or plates) are synonymous terms.
- Only continents move, not plates.
- Divergent ocean ridges are due to vertical uplift or convergence, rather than divergence.
- Oceans are responsible for oceanic crust (rather than being closer to other way around).
- The edge of a continent is the same thing as a plate boundary.

From http://assessment.aaas.org/topics/PT#/

- Plates are made of melted rock.
- Plates are feet thick/several inches thick. The earth has seven plates/there is one continent per plate.
- Earth's plates are piled on top of each other like dinner plates.
- Ocean basins are not part of earth's plates.
- Continents float on a layer of water, and the water is above a plate.
- Plate boundaries only occur where continents meet ocean basins.
- Continents are on top of plates but are not part of plates.
- Earth's plates are not in contact with each other/Earth's plates are separated by empty gaps/Earth's plates are separated by oceans/Earth's plates are surrounded by melted rock so that the plates are not touching each other.
- Continents are next to plates, but not part of plates.
- Plate boundaries cannot occur within a continent.
- Earth has about one hundred plates.
- Earth's plates are made of sand.
- Earth has one very large plate.

From http://www.nsta.org/publications/news/story.aspx?id=52474:

- Earth is becoming smaller because of subduction/larger because of divergence of plates.
- Pangaea broke apart a long time ago. Now the continents are coming back together on the other side of Earth.
- A giant meteor/earthquake caused Pangaea to break up.
- All plates move in the same direction and at the same speed.
- Plate motion cannot be measured because it is so slow.
- If plates are moving apart two centimeters per year, that distance is so insignificant that it could never be noticed.
- Since the super-continent Pangaea split up ~200 million years ago, the continents have remained in essentially the same positions.
- The fact that the east coast of South America and west coast of Africa have shapes that would fit together like a jigsaw puzzle is just a coincidence.
- Continents (and plates) do not move/can never join together/cannot split and become smaller.
- It is impossible for the continents to have been parts of one large continent in the past.
- Plates are the same size and shape now as they've always been.
- The plates move, but they have no effect on one another.
- There is no way to determine the location of boundaries between plates.
- All changes to Earth's surface occur suddenly and rapidly.
- All events that affect Earth are gradual or slow.
- All Earth processes operate at the same rate (on the same time-scale).
- All changes to Earth occur so slowly that they cannot be detected during a human lifetime.

Earth and Human Activity: MS-ESS3-1

back to "Item Specifications by Performance Expectation"

MS-ESS3-1. Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.

OAS-S Clarification Statement:

Emphasis is on how these resources are limited and typically non-renewable, and how their distributions are significantly changing as a result of removal by humans. Examples of uneven distributions of resources as a result of past processes include but are not limited to petroleum (locations of the burial of organic marine sediments and subsequent geologic traps), metal ores (locations of past volcanic and hydrothermal activity associated with subduction zones), and soil (locations of active weathering and/or deposition of rock).

OAS-S Assessment Boundary:

(none)

Science & Engineering Practice:	Disciplinary Core Idea:	Crosscutting Concept:
Constructing Explanations and Designing Solutions • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**ESS3.A: Natural Resources** • Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. • Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. • These resources are distributed unevenly around the planet as a result of past geologic processes.	**Cause and Effect** • Cause-and-effect relationships may be used to predict phenomena in natural or designed systems.

In Lay Terms:

Students should be able to explain the cause-and-effect relationship between the unequal distribution of Earth's resources and the geological processes that led to their formation, and how the current distribution of resources is influenced by rates of usage that exceed rates of replenishment.

Cluster Clarifications:

- Students will use as evidence examples of each type of earth resource (minerals, energy sources, groundwater).
- Clusters may focus on explaining the past geological processes that have caused distributions of resources OR focus on explaining the current distributions of resources as a result of past geological processes; both approaches fit the performance expectation.

Cluster Stimulus Attributes:

Typical stimulus elements:

- diagrams of distribution of resources and environmental conditions of formation
- graphs of resource availability
- text descriptions of resource formation and/or distribution

Possible contexts:

- Yellowstone—current processes showing energy release
- maps showing distribution of oil reserves or coal beds across the world, within state (what characteristics do these areas have in common?)
- comparison of Crater of Diamonds State Park diamond mine in Arkansas to diamond deposits in South Africa
- formation/location of salt domes in Gulf of Mexico
- distribution of oil within the earth's layers
- Garber sandstone and red color of soil in Oklahoma City

Content and evidence to be included: data/information related to resource distribution, usage/depletion of resources, and environmental characteristics of locations

Types of student responses that need to be supported: using evidence and reasoning to provide explanations of cause-and-effect related to formation and uneven distribution of resources

Allowable Item Types:

- MC
- TEI

Model Item Descriptions for MS-ESS3-1:

#	Item Type	DOK	Model Stem (Items ask students to…)	Response Characteristics*
1	**MC**	1 or 2 per complexity	Explain cause-effect relationships between the uneven distribution of Earth's resources and past and present geological processes. [Based on the data presented, what accounts for the difference in soil color in different parts of Oklahoma (e.g., Garber sandstone)?]	Distractors may include statements that do not sufficiently explain; statements that explain alternate phenomena; or statements lacking critical conceptual connections.
2	**MC**	2 or 3 per complexity	Identify the evidence that supports conclusions related to the causes of unequal distribution of natural resources. [What data (table related to drought and aquifer level) support the conclusion that certain areas within the state of Oklahoma are prone to drought (e.g., 10 year and 5 year drought areas)?] [Which evidence explains the location of salt plains (in Oklahoma) in the diagram?] [A student concluded that because oil is formed from the remains of plants, oil should be found in a pool just below the Earth's surface. Which statement explains how the diagram of rock layers and the data table support a different explanation?]	Distractors may include statements explaining reasoning for other outcomes of distribution, or erroneous explanations.
3	**MC**	1 or 2 per complexity	Explain the relationship between limited/non-renewable resources and time of formation or rarity of environmental characteristics of formation. [Based on the information (coal mining map of Oklahoma showing swamp areas of past era overlaying with current coal lines/natural gas), how/why did the past environment of Oklahoma affect the current deposits of gas/coal?]	Distractors may include alternate explanations for formation or rarity of resources or alternate statements with incomplete or invalid explanations.
4	**MC**	2 or 3 per complexity	Identify the explanation for the mechanism of distribution of resources. [Which of the following explains why most of the sand mines shown in the diagram are located within river systems?] [Which statement explains why so many towns in Oklahoma have sulfur in their water supply?]	Distractors may include statements applying alternate mechanisms, or statements about non-renewable resources unrelated to the mechanism.
5	**MC**	2	Identify the evidence that supports the explanation for how limited/non-renewable resources are formed. [What evidence supports the students' explanation for why fossil fuels are non-renewable?]	Distractors may include data that do not provide sufficient/valid evidence or data related to other formation processes.
6	**MC**	2	Describe the reasoning that connects the evidence of uneven distribution of resources to rarity of environmental factors involved in their creation.	Distractors may include statements including invalid/unsupported reasoning, or reasoning for alternate phenomena.

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
7	**MC**	2	Describe the reasoning that connects the depletion of resources and time scale of replenishment to the limited availability of non-renewable resources.	Distractors may include statements including invalid/ unsupported reasoning, or reasoning for alternate phenomena.
8	**MC**	2	Describe the reasoning that connects the depletion of resources to their uneven distribution worldwide.	Distractors may include statements including invalid/ unsupported reasoning, or reasoning for alternate phenomena.
9	**MC**	2 or 3 per complexity	Identify which statement/clarification will best improve the explanation of formation of limited/ non-renewable resources or uneven distribution of such resources.	Distractors may include information/data/trivial statements that do not provide an improved explanation.
10	**MC**	2 or 3 per complexity	Explain how the type of extraction of resources changes how much and where additional resources can be found.	Distractors may include incomplete or incorrect descriptions/explanations.
11	**MC**	2 or 3 per complexity	Explain how the data (maps showing rock formations and locations of oil wells/mineral deposits) can be used to effectively explore for oil/ minerals.	Distractors may include explanations that show incorrect or incomplete cause-effect relationships.
12	**MC**	2 or 3 per complexity	Explain how an engineer could use the data to find the best location to create a certain feature or usage (e.g., a reservoir, by damming the river).	Distractors may include explanations that show incorrect or incomplete cause-effect relationships.

*Response options can make use of Student Misconceptions (examples of scientifically incorrect assumptions) related to this performance expectation; references to misconceptions are listed in the link(s) below:

From http://hub.mspnet.org/media/data/MiTEP_List_of_Common_Geoscience_Misconceptions.pdf?media_000000007297.pdf:

- If we run out of oil and gas we will just find more.
- "Man-made" materials do not come from mineral resources.
- Few products we use every day have anything to do with taking rocks and minerals from the ground.
- Earth and its systems are too big to be affected by human actions.
- Earth is both an endless supply of resources and a limitless sink for the waste products of our society.

Earth and Human Activity: MS-ESS3-2

back to "Item Specifications by Performance Expectation"

MS-ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

OAS-S Clarification Statement:

Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).

OAS-S Assessment Boundary:

(none)

Science & Engineering Practice:	Disciplinary Core Idea:	Crosscutting Concept:
Analyzing and Interpreting Data • Analyze and interpret data to provide evidence for phenomena.	**ESS3.B: Natural Hazards** • Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces, can help forecast the locations and likelihoods of future events.	**Patterns** • Graphs, charts, and images can be used to identify patterns in data.

In Lay Terms:

Students should be able to transform and interpret data related to natural hazards to describe patterns and predict the likelihood of future occurrence. Additionally, students should be able to relate hazards data to technologies intended to mitigate the effects of these hazards.

Cluster Clarifications:

- Fracking and earthquakes associated with fracking are controversial in Oklahoma and should be avoided as context.
- The performance expectation includes interpretation of maps showing frequency of storms, movement of hurricanes, tornadoes, winter storms, etc., satellite imagery of rainfall intensity and flooding, etc.
- Students are not responsible for knowing names/characteristics of earthquake waves or for triangulation of epicenter of an earthquake, but may be asked to analyze data related to speeds or amplitudes of waves.
- Students are not responsible for memorization of names of clouds or association of particular cloud types with weather. However, students may be asked to draw inferences about such information when provided.

Cluster Stimulus Attributes:

Typical stimulus elements:

- diagrams
- tables
- charts
- maps
- graphs or text descriptions of past natural hazards

Possible contexts:

- data related to hazards may include, but are not limited to:
  - New Madrid seismic area—68 quakes/year
  - faults extending through Oklahoma
  - non-fracking-related earthquakes in Oklahoma
  - wind movement data: hurricane, tornado paths
  - overlays of volcanoes, earthquakes, and plate boundaries
  - earthquake frequency data (preceding volcanic eruption)
  - relationship between wildfires and flash flooding
  - relationship between type/amount of groundcover and land/mudslides (e.g., mudslide risk with English ivy)
- technologies and data relating technologies and hazards may include, but are not limited to:
  - roof types, construction, and bracing systems
  - storm shelters (e.g., number of storm shelters purchased by states [ones with tornadoes vs. ones without])
  - coastal house structure (stilts, shutters, breakaway walls)
  - maps relating tsunami warning system to particular coastal areas (e.g., data showing ring of fire)
  - maps showing U.S. tornado distribution connected to precautions, shelters
  - distribution of houses with basements/shelters
  - satellite systems for predicting storms
  - systems for alerting populace to immediate hazard (Emergency Broadcasting System, National Weather Service alerts, watches, warnings)
  - forest "Fire Danger Today" signage; lookout towers
  - use of seismometers, ground deformation tools, and gas capture tools to analyze and predict volcanic eruptions
  - dikes, dams, and floodgates
  - use of channels/barriers on volcanoes to direct flow of small lahars

Content and evidence to be included: data relating natural hazards to preceding phenomena; data recording location, timing, and severity of hazards; historical data showing likelihood or hazard; data relating hazards to technologies intended to warn or mitigate damage.

Types of student responses that need to be supported: transforming data; describing patterns and conclusions from data; making predictions from data; analyzing the relationship between hazard data and development/usage of warning and mitigation technologies

Allowable Item Types:

- MC
- TEI

Model Item Descriptions for MS-ESS3-2:

#	Item Type	DOK	Model Stem (Items ask students to…)	Response Characteristics*
1	**MC**	1	Describe/read data in tables, graphs, and diagrams (about natural hazards and use of technology to prevent/mitigate hazards). [Based on the data in the graph and table, in which states are tornadoes most likely to occur?] [For which natural hazard is (city/town) most at risk?] [What process is represented by this data set?] [Based on the information in the map, what type of damage was caused by this (undersea) earthquake?]	Distractors may include misinterpretations resulting from incorrect reading of graphs, tables, and diagrams, or other data points found in the stimulus.
2	**MC**	1 or 2 per complexity	Describe simple patterns and trends in tables, graphs, and diagrams (about locations, frequency, severity, types of damage). [Based on the data in the graph, how many times more powerful is a magnitude 7 earthquake compared to a magnitude 6.5 earthquake?] [Based on the data in the graph and table, what is the relationship between the depth of an earthquake and the amount of damage caused?] [Which statement describes how wave characteristics change as they travel through different layers of the earth?] [What similarity can be seen between these two data sets?]	Distractors may include responses indicating incorrect understanding of trends and patterns.
3	**MC**	1 or 2 per complexity	Transform tabular or text-based data related to natural hazards into the form that best emphasizes the patterns within the data. [Which graph should be used to most clearly show the relationship between depth and energy of an earthquake on Earth's surface?] [Which graph best shows the relationship between amplitude and energy of an earthquake?] [How should this data table be reordered to make the pattern in the data easier to see?]	Distractors may include graphs that are better suited to other functions, such as scatterplot, bar graph, histogram, or pie graph.
4	**MC**	2 or 3 per complexity	Draw specific conclusions about the use of technologies in terms of predicting or mitigating natural hazards, based on information provided. [In which location would a tsunami warning system be most useful?] [Based on the information in the diagram, how are seismographs used to predict a volcanic eruption?] [Based on the evidence presented in the diagram, why do coastal homes often contain breakaway walls?] [Based on the data showing past river levels, what is the most cost-effective way to alter levees along the Mississippi River to prevent flooding, if water levels along the Missouri River rise to (X) level?]	Distractors may include conclusions that result from incorrect interpretations of the trends or patterns found in the data.

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
5	**MC**	2 or 3 per complexity	Predict the occurrence of a natural hazard (type, location, likelihood, severity, duration, etc.) [Based on the data, which town or city is most likely to be affected by a lahar if Mt. Hood erupts to the west?] [Based on the data in the table, what events will most likely precede an eruption of Mt. Saint Helens?] [Based on the data, for how long will city X most likely experience aftershocks after a magnitude 7 earthquake?]	Distractors may include predictions that result from incorrect interpretations of the trends or patterns found in the data.
6	**TEI**	3	Analyze data showing simple trends to identify the severity or type of damage caused by natural hazard events. [Use the data in the table to identify and show the type of damage sustained by the towns on the map (by dragging symbols for ash fall, lahar damage, pyroclastic flow).] [The table shows changes to crops grown near the volcano Sakurajima. Use the information to label where the most crop failures likely occurred, as a result of toxic gases flowing from the volcano (by dragging arrows to a graph).]	Drag-drop interaction. Correct responses show all symbols, labels, or indicators in correct locations/positions. Partial credit would be given for a subset of correct answers.
7	**MC**	3	Analyze data showing complex patterns or trends, to make predictions about the likely effects of a natural hazard. [Based on the information in the table (soil types and degree of liquefaction/earthquake shake table simulation), which location in the city is at greatest risk of damage from an earthquake that measures 6.5 on the Richter scale?] [What type of damage will this city most likely sustain if a tsunami occurs?]	Distractors may include predictions made from only a portion of the relevant data.
8	**MC**	2 or 3 per complexity	Explain *how* the specific data/evidence support the conclusion or prediction about natural hazards/events. [How do the data support the conclusion that invasive species such as English ivy are linked to an increase in landslides?] [How do the data support the conclusion that some volcanic eruptions can be predicted?]	Distractors may include misconceptions or explanations that misinterpret the pattern seen in the data.
9	**MC**	2 or 3 per complexity	Determine which data set shows a pattern most like another or most likely to occur in another location. [Based on the data, which statement identifies the eruption that was most similar to the eruption of Pinatubo, and explains these similarities?]	Distractors may include other data provided and erroneous or irrelevant descriptions of similarities.
10	**MC**	2 or 3 per complexity	Predict the pattern that will most likely occur based upon the data provided. [Based on the data table and map, where is the most likely landfall for the hurricane shown?]	Distractors may include predictions that interpolate or extrapolate data that is irrelevant or inconsistent with the pattern described.

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
11	**MC**	3	Use data to evaluate the effectiveness of mitigation techniques. [Based on the data, which action is most likely to reduce the damage from a storm surge in a low lying coastal area?]	Distractors may include explanations of actions that will be less effective at mitigating damage.
12	**MC**	2 or 3 per complexity	Describe the pattern in the data that supports a given conclusion related to natural hazards or their mitigation. [Which pattern supports the conclusion that hurricanes' intensity is linked to water temperature?]	Distractors may include descriptions of patterns that are incorrect interpretations of data, or which are irrelevant to the phenomenon being studied.

*Response options can make use of Student Misconceptions (examples of scientifically incorrect assumptions) related to this performance expectation; references to misconceptions are listed in the link(s) below:

From http://serc.carleton.edu/NAGTWorkshops/intro/misconception_list.html:

- Earthquakes and volcanic eruptions are rare events.
- Floods are atypical, almost unnatural events rather than normal river behavior.

From Earth Science Misconceptions, Philips, February 1991.
http://k12s.phast.umass.edu/~nasa/misconceptions.html:

- Floods along rivers happen only after snow melts in the spring.

From http://hub.mspnet.org/media/data/MiTEP_List_of_Common_Geoscience_Misconceptions.pdf?media_000000007297.pdf:

- Natural disasters happen very rarely and these events are just the bad luck of the people that are affected.
- Hazards are random in both time and place and just bad luck.
- A 30-year, 100-year, or 500-year flood means that these are set time intervals between flooding events.
- All natural disasters have only local effects.
- Flooding only occurs after a heavy rainfall.
- Volcanic ash only affects communities close to a volcano.

Earth and Human Activity: MS-ESS3-4

back to "Item Specifications by Performance Expectation"

MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

OAS-S Clarification Statement:

Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as fresh water, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.

OAS-S Assessment Boundary:

(none)

Science & Engineering Practice:	Disciplinary Core Idea:	Crosscutting Concept:
Engaging in Argument from Evidence • Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or solution to a problem.	**ESS3.C: Human Impacts on Earth Systems** • Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.	**Cause and Effect** • Cause-and-effect relationships may be used to predict phenomena in natural or designed systems.

In Lay Terms:

Students should be able to analyze data to construct or evaluate an argument related to the cause-and-effect relationship between population growth and resource usage, or to evaluate proposed solutions to problems related to population growth and resource usage.

Cluster Clarifications:

- Use the term "reject" in place of "refute."
- The major cash crops in Oklahoma are wheat, greenhouse products, hay, cotton, soybean, corn, and fruits and nuts including pecans, peanuts, watermelons, and peaches.
- Use sensitivity when discussing water usage or potential replacement of crops, or use examples from outside of the state (e.g., California drought and crops requiring intensive watering).

Cluster Stimulus Attributes:

Typical stimulus elements:
- graphs
- data tables
- diagrams
- text explanations

Possible contexts:
- sustainability, overpopulation (e.g., number of trees planted versus harvested)
- graphs showing/comparing Oklahoma/U.S./global population growth or alternative energy sources, solar, wind, natural gas versus gasoline, compressed natural gas
- eating lower on the food chain
- relative water usage of crops and total crops that can be grown as result (e.g., corn as alcohol group versus soybeans as protein/oil crop); California almond crop and water usage
- decrease in farming of species raised in water (e.g., fish) in Oklahoma over past decade; use of surface water

Content and evidence to be included: real-world data models or data comparisons of human population growth and consumption, diagrams/drawings, graphical representations, scientific arguments/conclusions, and case study results related to human population growth, resource consumption, and impacts to Earth systems as a result of population growth and consumption

Types of student responses that need to be supported: describing or explaining trends or factors; identifying explanations supported by claims; evaluating the validity of claims and reasoning for a claim

Allowable Item Types:
- MC
- TEI

Model Item Descriptions for MS-ESS3-4:

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
1	**MC**	1 or 2 per complexity	Identify/describe the evidence that supports/ rejects a claim related to the relationship between population growth and resource usage. [Which evidence supports the student's claim that population growth is the cause of negative effects to Earth's supply of natural resources?] [Which evidence could be used to support the claim that increases in farming of foods for export has had a negative impact on local usage/supplies of water/gas and oil?]	Distractors may include evidence that is irrelevant or does not appropriately align with the evaluation of the claim.
2	**MC**	2	Describe *how* a given data set supports or rejects an argument about the relationship between population growth and resource consumption. [How does the decrease in population at time X in this model system support the claim that population growth affects cycling of carbon dioxide?] [How does the information comparing the production of soybeans and beef support the argument that eating lower on the food chain reduces resource consumption?]	Distractors may include descriptions that incorrectly explain how the given data support or reject the argument, or that show a misunderstanding of the premises of the argument.
3	**MC**	2 or 3 per complexity	Evaluate arguments related to resource usage to choose the one that is best supported by the data in a graph/table. [Which argument about water usage for almond production is best supported by the data in the table?]	Distractors may include arguments that are only partially supported by the data, or which are not supported by the data.
4	**MC**	2 or 3 per complexity	Select the reasoning that best supports the claim/ conclusion regarding the cause-effect relationship. [Which reasoning best supports the scientists' conclusion about the type of impacts that are likely to result from deforestation?]	Distractors may include reasoning that incompletely supports the claim or conclusion, or that could be used to reject the conclusion.
5	**MC**	2 or 3 per complexity	Evaluate data in support of a claim made in a model. [Which claim made in the students' population growth model is best supported by the data?] [Which data best support the claim that as the life span of humans has increased, natural resources have been negatively affected?]	Distractors may include evaluations of data which incorrectly assign importance to irrelevant results, or claims which are not supported by the data shown.
6	**MC**	2 or 3 per complexity	Evaluate the merit of a claim based on data or evidence. [Which statement best describes the merit of the claim made by Group X about the impact of clear-cutting on future resource availability?]	Distractors may include reasoning about merit that does not follow from the data presented in the stimulus.

#	Item Type	DOK	Model Stem (Items ask students to...)	Response Characteristics*
7	**MC**	2	Describe the argument that best supports or rejects the claim based on the evidence. [Which argument best rejects the claim that the model population described in the experiment will be able to double in the next four hours?] [Which argument best supports the claim that increases in the size of the human population will affect the amount of fresh water available to individuals and communities?]	Distractors may include arguments which incorporate misconceptions and/or evidence irrelevant to the claim.
8	**MC**	2 or 3 per complexity	Explain how the evidence provided supports one claim but not an alternative claim(s). [How does the evidence support claim 1 over claim 2?] [What evidence would be required to support claim 2 over claim 1?]	Distractors may include explanations that do not adequately explain the usefulness of the data to distinguish among claims.
9	**MC**	3	Use reasoning to qualify additional support for a claim or argument. [Which additional evidence will strengthen the scientists' argument about the effect of an increased standard of living in China?]	Distractors may include evidence that can be used to reject the claim or is irrelevant or neutral to the claim.
10	**MC**	2 or 3 per complexity	Describe the evidence that best supports/rejects an argument related to the use of engineering solutions to reduce or mitigate resource consumption. [Which evidence best supports the argument/claim that aquifer recharge systems can help to reduce the stresses placed on aquifers by growing cities?] [Which evidence best supports the argument that native landscaping reduces the amount of water used weekly by households?]	Distractors may include evidence that is either essential or unessential to support a claim, depending on wording of stem.
11	**MC**	3	Distinguish the evidence and/or reasoning that best improves/supports the scientific reliability of an argument or conclusion. [Which additional evidence should be collected to have enough evidence to support the claim?] [Which evidence is <u>least useful</u> to support the claim that insects as a food source have less impact on natural resource usage?]	Distractors may include evidence that is either essential or unessential to support a claim, depending on wording of stem.

*Response options can make use of Student Misconceptions (examples of scientifically incorrect assumptions) related to this performance expectation; references to misconceptions are listed in the link(s) below:

From http://hub.mspnet.org/media/data/MiTEP_List_of_Common_Geoscience_Misconceptions.pdf?media_000000007297.pdf:

- If we run out of oil and gas we will just find more.
- "Man-made" materials do not come from mineral resources.
- Green energy leaves no carbon footprint.
- Few products we use every day have anything to do with taking rocks and minerals from the ground.
- Earth and its systems are too big to be affected by human actions.
- Earth is both an endless supply of resources and a limitless sink for the waste products of our society.

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